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# COMPARING CONVENTIONALLY LANDFILLED SOLID WASTE WITH PROCESSED LANDFILLED SOLID WASTE

FLOYD G. BROWN AND ASSOCIATES LTD.

PREPARED FOR

ENVIRONMENTAL PROTECTION AGENCY

1973

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# COMPARING CONVENTIONALLY LANDFILLED SOLID WASTE WITH PROCESSED LANDFILLED SOLID WASTE

Final Report On a Solid Waste Demonstration Grant Report

This report was prepared by Floyd G. Browne and Associates, Limited
Robert C. Jones, Project Director, under grant No.1-G06-EC-00297
from the United States Environmental Protection Agency
Office of Solid Waste Management Programs

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August 7, 1973

United States Environmental Protection Agency
Office of Solid Waste Management Programs
5555 Ridge Avenue
Cincinnati, Ohio 45268

SUBJECT: GRANT PROJECT NO. G06-EC-00297

Gentlemen:

In accordance with the Terms and Conditions of the Grant, we submit six (6) copies herewith of the final report for the evaluation of the Cobey Roto-Shredder and the construction and operation of the test cells for the Crawford County, Ohio Demonstration Grant No. G06-EC-00297.

It is our understanding after the report has been reviewed and corrected, if required, the resubmitted corrected report will be printed by the Office of Solid Waste Management Programs. We would like to be kept informed as to the decision to print the report and when it will be available for distribution.

We are pleased to have had the opportunity to work with and to serve the United States Environmental Protection Agency, Office of Solid Waste Management Programs on this Project and would again welcome another Project with this Office.

Very truly yours,

FLOYD G. BROWNE AND ASSOCIATES, LIMITED

Robert C. Jones

Robert C. Jones, P.E.
Project Director

RCJ/fbh

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# CHAPTER I

# GENERAL DESCRIPTION OF PROJECT

## INTRODUCTION

CRAWFORD COUNTY, STATE OF OHIO, conducted a one year demonstration project of research and investigation to develop a satisfactory method of trench landfilling processed solid waste material. The Project was developed in cooperation with the United States Environmental Protection Agency, Office of Solid Waste Management Programs, Processing and Disposal Division, the Crawford County Ohio Commissioners and was funded in part by a Solid Waste Disposal Demonstration Grant No. 1-G06-EC-00297. Although sanitary landfills have been and are being scientifically studied, there still remains much scientific data and practical economic information on the various types of landfill operations yet to be obtained.

The Project includes the economic investigation of a relatively new piece of equipment for use in treatment of solid waste before landfilling. The machine is called a Roto-Shredder and is manufactured by the Roto-Shredder Company, a Division of Imco, Crestline, Ohio, which is located in Crawford County. The different methods of landfill operation investigated were:

1. Trench landfilling conventional solid waste
2. Trench landfilling shredded solid waste
3. Trench landfilling rough composted solid waste

## BACKGROUND

The processing of solid waste by shredding or composting is not a new concept in solid waste management. The landfilling, using the trench method, of shredded or composted solid waste is relatively new, untried and

not previously scientifically studied. A Demonstration Grant Project at Madison, Wisconsin, was making an economic study of landfilling milled solid waste at the same time as the Crawford County, Ohio, study. Composting methods were being studied in Florida, Texas, California, Ohio and other states all with the purpose of selling the end product.

The end product after processing at the Crawford County Sanitary Landfill would not be for sale but for landfilling. The Crawford County operation was set up to receive all the solid waste generated in the County and the only wastes excluded are the automobile, farm machinery and toxic liquids. It soon became apparent that some of the incoming solid waste could not be shredded or composted using the Roto-Shredder. A limiting consideration of the Project was not to add sophisticated operating equipment to the extent that the operation would not be classified a landfill operation and could not be compared to a conventionally operated sanitary landfill.

PROJECT OBJECTIVES

The principal objectives of the one year Demonstration Grant were as follows:

1. To compare the standard trench type sanitary landfill and particularly the degree of compaction which can be obtained by conventional crawler type equipment to a similar operation preceeded by shredding or shredding and then rough composting of the raw refuse on the site with the use of the Roto-Shredder.
2. To improve the efficiency and economics of windrow composting without pre-salvaging or pre-grinding by using the Roto-Shredder treatment method.

3. To study the possibility of using finished rough compost for covering shredded or conventionally landfilled material and for use as a final cover for the trenches.

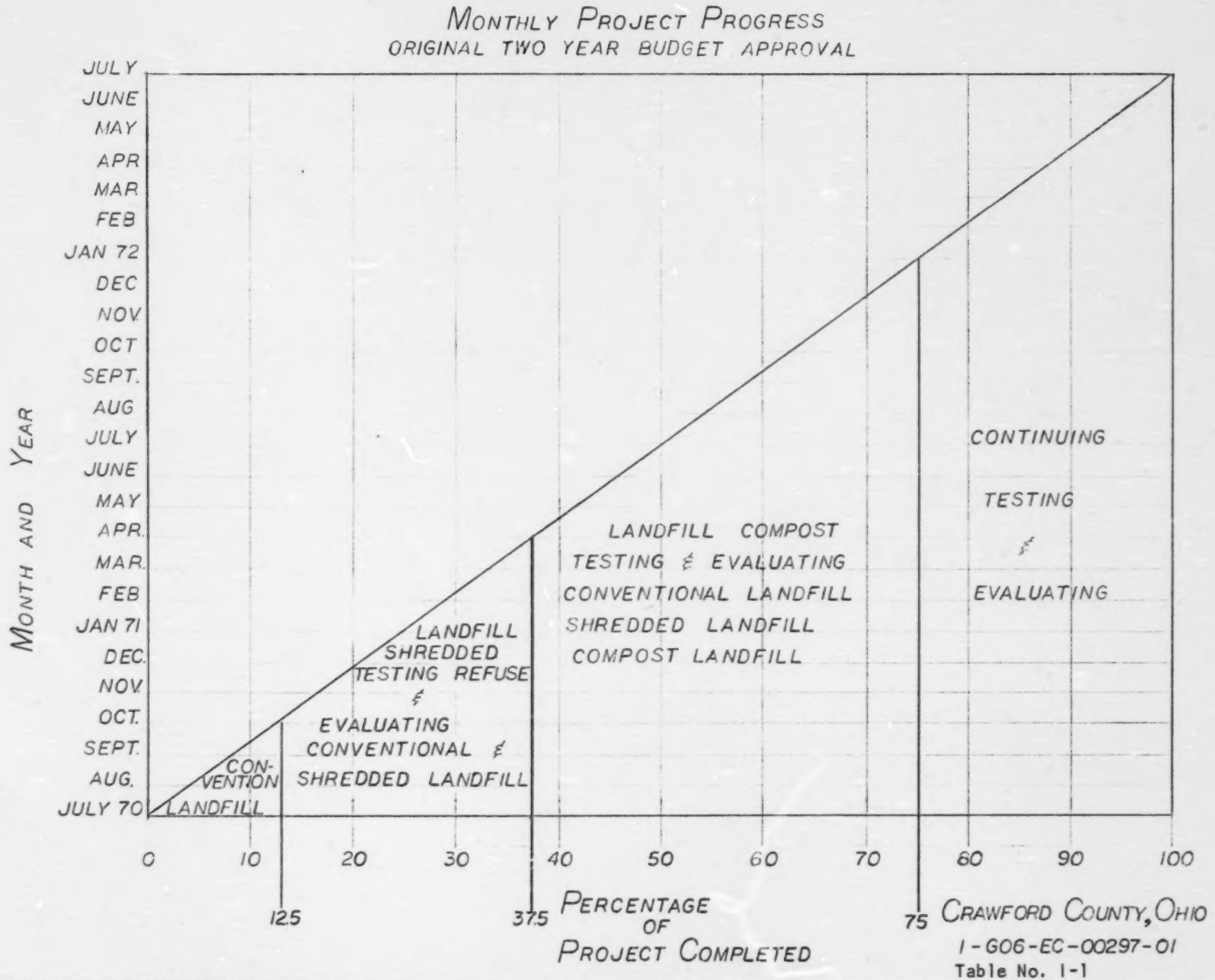
4. To study the ecological differences caused by the trench landfilling of different processed material through the specific laboratory analysis of samples of gas, leachate, and solid materials collected from specially constructed field cells.

Table No. I-1 shows the proposed Monthly Project Progress for the two year Grant Budget period as per the original approved Grant Application.

PROJECT PERSONNEL

The following people contributed much to the planning and consultation of the Project:

| | |
|---|---|
| U.S. EPA Project Officers | Mr. Stan Endlich<br>Mr. Peter R. Johnson<br>Mr. J. Robert Holloway<br>Mr. James F. Mank |
| Consultants | Dr. John R. Snell, P.E.<br>John R. Snell Engineers, Inc. |
| | Dr. Norman R. Sedlander<br>Professor Civil Engineering<br>University of Toledo |




CRAWFORD COUNTY, OHIO
1-G06-EC-00297-01
Table No. 1-1

## CHAPTER II

## THE SANITARY LANDFILL SITE

### GENERAL DISCUSSION

The Crawford County Sanitary Landfill is a fairly new operation. It was opened in November of 1969 to serve the entire County. The detailed plans and operating specifications were approved by the State of Ohio Department of Health under the Ohio Solid Waste Disposal Law and Regulations adopted May 18, 1968.

### GEOGRAPHIC LOCATION

The landfill area contains 198 acres of land located in Section 2, Whetstone Township and Section 35, Liberty Township, Crawford County, Ohio. It is located on U.S. 30N approximately 5-1/2 miles from Bucyrus, the County Seat, approximately 7 miles from Crestline and approximately 10 miles from Galion, the three largest cities in the County. Since the area is relatively flat, just as is most of the Northwest Ohio area, the landfill is operated using the trench method for solid waste disposal.

### SOIL CONDITIONS

The soil material in the landfill area is primarily clay or a clay loam and is highly compacted calcareous glacial-till. Because only a small amount of water can filter through the compacted glacial-till material, water ponding and soil wetness are not an unusual occurrence. The ground water table was not encountered in a 15 foot zone below the surface. Investigations show it is not expected to occur in the compacted till zone which extends several feet below the 15 foot depth.

The test holes used to evaluate the soil conditions showed the trench walls would be relatively stable. Where sloughing did occur, it was in

the saturated layers that lie above the glacial-till. This makes the trench method not only practical but allows trench to be opened three or four days ahead of the working face.

The excavated material from the trenches is fairly easy to work providing it does not become too wet. If it becomes wet, it is somewhat sticky, plastic, and difficult to handle. When the material is compacted, it is relatively impervious.

DETAILS OF SITE DESIGN

The solid waste material to be received is a typical mixed refuse including residential, commercial and industrial wastes. It is all trucked to the site in packer trucks, dump trucks, pickup trucks, trailers and automobiles. Before the disposal facility was opened, the landfill site was constructed following plans approved by the State Health Department. The entry roadway was constructed with an asphalt top and drainage ditches. The maintenance and office building were completed with the weigh scale installed. The first trench was prepared with an access road graded, stoned and drained to the one end of the trench. Snow fencing was installed to help control blowing papers and plastics and would be moved as the working area moved along the trench. The trenches are dug 30 feet wide and 15 feet deep.

METHOD OF OPERATION

The landfill is operated on a cost per weight basis. All loads except the automobile and station wagon are weighed on a scale and charged accordingly. The automobile and station wagon are directed to metal containers with spring latched doors located at the side of the maintenance building for their disposal area. This keeps small vehicles away from the working area. These containers are picked up by a commercial hauler who hauls

solid waste to the landfill and during his trips carries the containers to the working area and empties them. The vehicles passing over the scale are directed to the working area where they dump or hand unload their waste over the side of the trench. The landfill is open from 8:30 a.m. to 4:00 p.m. five days a week and from 8:30 a.m. to 12:00 noon on Saturday and closed on all Sundays and holidays.

The landfill is operated by three persons namely a Director of the landfill who also operates the excavating equipment, a dozer operator who spreads, compacts and covers the solid waste and a weight scale operator. The Director has the responsibility of keeping the entire operation operating in accordance with the Solid Waste Laws of the State. He must plan for all four seasons of the year and be able to operate every day as a sanitary landfill; deposit the material on the working face, spread the material in layers, compact the layers and cover all the material with six inches of earth before the day if over. A periodic general cleaning is programed at least once a week to pick up papers and plastics around the fenced area and drippings along the access road.

OPERATING EQUIPMENT

The operating equipment at the landfill consists of one heavy duty 3/4 cubic yard Lima Dragline, one 977K Caterpillar Crawler Loader with a multipurpose bucket for spreading, compacting and covering the solid waste. The auxiliary equipment includes a used road grader to maintain roads, a dump truck to haul stone for road repair and a small farm rubber tired loader used to clean the edge of the trench. A yearly renewable contract is kept enforced between the County and a road machinery dealer to supply standby equipment for the dragline or crawler loader during down time. The remaining equipment consists of a 2 inch pump, a compressor to clean

the raditor of the loader and small repair tools for preventative maintenance of all the equipment.

The maintenance building and actual trench landfill operation are shown by Figures 1 and 2.

Fig. 1. Maintenance Building with office and scale entry road and equipment maintenance area in rear portion of building.

Fig. 2. Typical trench showing 977K Crawler Loader spreading and compacting waste with rubber tired loader cleaning edge of trench.

# CHAPTER III

# THE CONVENTIONAL LANDFILL STUDY

Since the Crawford County landfill was newly created, no data was available on cost of operation or characteristics of community refuse. Therefore before an evaluation could be made on the landfilling of pre-treated refuse, a study based on conventional landfilling had to be made. This section of the report deals with the gathering and interpretation of this important information.

## ASPECTS TO BE STUDIED

### The Density of Filled Refuse

One of the most important characteristics of landfilled refuse is its in-place density. Factors such as nature of refuse, the amount of compaction obtained by equipment, and moisture content all help determine the density of the filled material. Density is an important aspect involved in the overall cost of a landfill operation. Since a customer is charged according to the weight of his refuse, higher densities mean larger incomes per acre of land used. With the price of land at a premium, substantial financial benefits can be incurred through the increase of refuse densities.

Increased densities also result in decreases in differential settlement which ultimately occurs after a landfill has been completed. A decrease in differential settlement increases the potential usefulness of the land which remains after the landfill is fully utilized.

A record was kept of the daily in-place densities of all conventionally filled refuse between September 14, 1970, and December 31, 1970. This was accomplished by measuring the volume of the refuse which had been compacted in the trench each day and compiling the weight of this refuse from the scale readings.

It was originally thought that information on compaction obtained due to number of passes by compaction equipment over refuse could also be provided but this proved extremely difficult under normal operating conditions. The primary aspect considered was the number of effective passes which the crawler made over the refuse. This depended ultimately on the type, the amount and the spacing of the refuse coming in. It did not seem feasible to utilize manpower for counting passes and recording this various information because it would be difficult to interpret and be unreliable at best.

Refuse Categories

In a county landfill area, all constituents of the community are represented. Residential, commercial, and industrial establishments each contribute to the solid waste disposal problem. Previous investigations have shown that variations of quantity occur from each of these contributors according to size and type of family or business and also according to the season of the year. The design of the landfill is enhanced if records of the various contributors are available. Often this information is not available because few accurate records are ever kept of refuse production in a county. It would be difficult to do so even if one wished because not all refuse is disposed of at a landfill. Salvaging by industry or private individuals, onsite burning, or other private disposal methods cloud the refuse picture. Effective control of disposal by responsible agents of the government can help to reduce this problem. Refuse at the Crawford County site was placed in the following categories: residential, commercial, and industrial. Daily records were also kept as to the company and the amount delivered.

Residential refuse is characterized by a mixture of glass, metal, paper, plastics, food wastes, yard trimmings which vary according to the

season of the year, and small amounts of other material. Previous attempts at pre-treating municipal refuse using mechanical processes have proven difficult and costly because of its varying and diverse composition. Landfill disposal has proven most successful so far.

Commercial refuse is characterized by a large amount of paper and paper products with some food waste and other material mixed in. Chief producers of commercial refuse include retail and wholesale stores, gas stations, schools, hospitals, commercial and professional offices, and other similar institutions.

Industrial refuse can consist of varying mixtures of garbage and combustibles, non-combustibles, construction material, fly ash, sludges, volatile liquid and non-volatile liquids. It is often difficult to determine whether refuse should be classified as commercial or industrial just on the nature of the firm's business as is often the case. In this situation an investigation of the refuse is needed.

METHODS OF EVALUATION

The method used to compare the various landfill disposal operations involves the determination of a cost per weight ratio, usually expressed in terms of dollars per ton, over a specified period of time. The variables involved in the operation of a conventional landfill make it difficult to determine a specific cost per weight ratio on a short term basis. Such things as seasonal changes in refuse quantities, added winter site improvements, operational costs, and unexpected repair costs make it nceessary to evaluate expenses on a yearly basis. After yearly expenses have been determined, they can be divided equally to fit the periods over which the landfill weight data is accumulated.

The weight data was recorded on a monthly basis but only full weeks were used for determination of a period. An example of this is the October period which runs from Monday, October 5, to Saturday, October 31. It was felt that by using full weeks, variations in daily tonnage would have no effect on the final values and that it would also be easier to determine expenses for the period.

Data was also kept on man work and machine operator hours. The evaluation of this data involves the consideration of human factors. As was found out during the conventional and shredding studies, the acceptance of the procedures and operations by the workers is a key to the success of the project. Increased man hours and fewer breaks in the work, turn the worker against new ideas and tend to undermine the potential advantages of a change.

COMPILING AND COLLECTING DATA

A full time employee was hired to collect data and compile this data into a form from which all operating costs were calculated. Work of the new full time employee consisted of measuring the trench width at the bottom, width at the mid-point and width at the top at 25 foot intervals of trench length at the beginning of the operating day. At the end of the day the compacted refuse was measured across the width at the 25 foot intervals of trench length and total length of trench used measured. The amount of cover material applied to the slope and top was also measured. From these measurements the density of compacted material could be figured plus the amount of cover used. At the end of each operating day the County scale records compiled from the scale weigh tickets and also tickets from automobiles and station wagons that were not weighed are all gathered and transferred to a master data sheet. The total gallons of

gasoline and fuel oil, quarts of oil and other items, such as repair parts, were written down for the record of total operating costs. The County Auditor supplied information such as payments on the purchase of the land, equipment, machinery, interest payments, and such records as payroll costs, which included insurance and retirement benefits. All these records were necessary to determine the total operating cost of the landfill.

Sample copies of the daily record sheets and monthly operating costs can be found in Appendix A of this report.

## CHAPTER IV

## LANDFILLING SHREDDED SOLID WASTE MATERIAL

The principle behind the process of shredding solid waste is to eliminate void spaces and to reduce the size of refuse material enough to create greater in-place densities after landfilling. Methods of reducing refuse such as hammer mills and portable shredders have been tested in the past, but the results of these investigations have shown them to be too costly to compete with conventional landfilling. A primary objective of this study is to examine a relatively new method for shredding refuse by the use of a Roto-Shredder Model 12 by Roto-Shredder Company, a Division of IMCO, of Crestline, Ohio. (See Figures 3 and 4.) This mobile self-propelled machine stradles windrows of unsorted refuse and travels the length of the row, tearing, shredding and grinding the material. After shredding is completed by one or more passes, the material is pushed into the landfill and the process begins again on a new windrow.

### ASPECTS TO BE STUDIED AND METHODS OF EVALUATION

#### Changes in Operation with Addition of Shredder

The high cost shown by previous studies involving the shredding or grinding of refuse resulted from the extra cost of additional equipment and site preparation over and above that needed for a conventional landfill. One of the most impressive proposed attributes of the Roto-Shredder seemed to be that it could be operated without any additional or specific site preparation. Although tests with the Roto-Shredder proved it to be operable under many adverse conditions, two problems did arise which influenced the shredding process to a great extent.

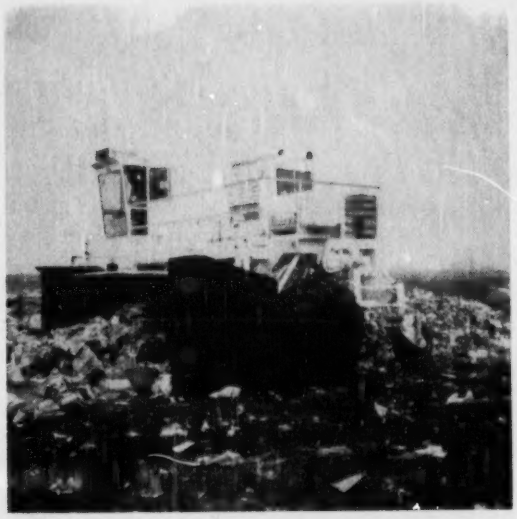


Fig. 3. Roto-Shredder moving forward into a windrow, shredded windrow behind.

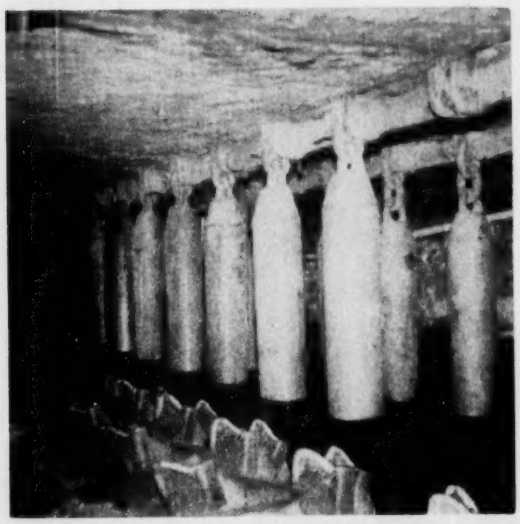


Fig. 4. Revolving drum with teeth which pick refuse up and throws it into hanging weights.

First was the problem of the vehicles which transport the refuse to the site not being able to operate with the Roto-Shredder without additional site preparation. Since the shredding operation took place during the Winter and Spring seasons of the year, moist soft ground caused the biggest problem. When the ground thawed, which occurred frequently, the trucks could not deposit the refuse in the shredding area near the trench for fear of getting stuck in the mud. Besides this, the mud they carried out on their tires and spread over the road could cause a considerable nuisance. Several loads of stone were ordered so that an area could be graded and prepared for accessibility by the refuse vehicles. This seemed to help the vehicles but it hindered the operation of the Roto-Shredder. The refuse material stuck between the void spaces of the stone and was hard to push into the trench and the continued turning action of the drum kept the stone from becoming compacted into the ground. Vehicle operators showed reluctance to drive over the area because they complained that broken glass which remained in the void spaces would ruin their tires. All this meant that additional site preparations would be necessary.

The second problem arose from the high winds which were characteristic of the season during which the shredding operation took place. The blowing of paper caused local authorities, who inspect landfill facilities to insure proper adherence to state and local regulations, to complain about the amounts of paper which could be found about the shredding area. It was finally decided that in order to continue operating, a 6 foot fence would have to be erected to catch any loose paper or debris that might be blown about. These conditional site preparations would surely mean increased costs and would decrease the favorable competition of the shredding process with the conventional landfill method. These additional

site preparations would be of a semi-permanent nature and the cost could be amortized over approximately six (6) months for the site preparation and three (3) years for the protective fencing.

These problems which occurred during the shredding operations hindered the experimental work to such a great extent that sufficient data could not be adequately gathered. High winds, extreme cold (below 10°F. temperature), wet and muddy conditions, and operational shut-downs prohibited shredding on 19 out of 24 days during the testing period in February. Data gathered during this period is presented so that the methods of evaluation can be reviewed. It is felt that insufficient data has been collected to determine any specific results at this time. Plans were made to begin the shredding operation after the composting test period if time permitted.

Densities and Refuse Categories

On January 18, 1971, the shredding operations began. A record was kept of all shredded and conventionally landfilled refuse, their in-place densities, the amount of refuse in each division. A record was also kept of the amount of refuse in each category: industrial, commercial and residential, just as had been done under the conventional study. It is not possible to shred all the refuse which comes to the landfill. The nature of industrial waste and some commercial material required it to be conventionally landfilled. The principal category which was shredded was residential refuse. If a residential load came in too late in the day and shredding could not be performed, it too would be landfilled conventionally, so as not to interfere with the over-all landfilling operating procedure.

Densitites were compared in two ways:

1. Placing the shredded refuse and the unshredded refuse in separate trenches

2. Placing the shredded refuse and the unshredded refuse in the same trench.

The purposes of landfilling two ways was to determine the amount of reduction that would be obtained strictly by shredding and to determine the best operational procedure for obtaining the greatest density. By placing the shredded refuse in a trench separate from the unshredded material, it would be possible to determine the amount of volume and size reduction and the increased in-place density which could be obtained by shredding refuse. The evaluation would include the examination of separate densities for shredded and unshredded material. A density for the total amount of landfilled material would also be obtained for comparison with a density obtained by the combined landfilling of refuse. The shredded and unshredded material was placed in the same trench to determine possible density changes that might occur from the filling of void spaces by the landfilling of similar shredded material.

Number of Passes and Drum Speed

A controversial aspect of the shredding operation among the people who operated and viewed it was the number of times the Roto-Shredder would have to pass through a windrow in order to be effective. A question was also raised as to how many passes would be needed to effectively shred the material and after how many passes would the shredding cease to be worthwhile. During the shredding period, the number of passes through the windrow was varied for evaluation of these questions. A refuse sieve was developed and a classification system was devised to assist in the evaluation. Information was gathered on refuse that had been shredded two and three times respectively. (See Tables IV-1 and IV-2 in Appendix B.)

Another variable which was thought to have a possible effect on the shredding operation was the speed of the shredding drum. Drum speed was evaluated to determine whether higher drum speeds would increase shredding efficiency and also if higher drum speeds would mean an increase in machine wear, maintenance, or fuel cost.

Additional Shredding After Test Cell Construction

During the last eight days of the first year of the Grant Project, after we were told that the Project would be terminated on June 30, 1971, we again moved the Roto-Shredder to the trench working area and completed the Project with eight days of shredding. The additional shredding was decided upon to gather more shredding data during the summer season. This shredding was done after completing construction of the six test cells which will be described in detail later in the report. During these days of shredding in the month of June we were able to operate without any site preparation because of the season of the year. In fact the stone placed during the month of February to improve the shredding area had been removed and piled in a stockpile to be used in the coming Fall and Winter.

As shown on Tables VI-3 and VI-4, Appendix B, the density figures and the shredding information pretty closely parallels the shredding that was done between the months of January and February. Additional information was accumulated such as, time for shredding a known amount of tons, time for the loader to put the material in the trench, and the time for the loader to compact the material in the trench. Also recorded was the time required to clean up the area, both equipment and the labor required. From information collected the conclusion reached was that it requires 0.006 acres of land to shred one ton of residential refuse using the windrow method and the Roto-Shredder to do the shredding. Using the recorded data

obtained during the last days of June the most accurate cost figures, the addition of the Roto-Shredder to the landfill for shredding windrowed material is estimated to be $.75 per ton over and above the conventional method of operation. An additional $0.25 per ton can be added for inclement weather operation due to special site preparation requirements.

Compiling and Collecting Data

The compiling and collection of data during the landfilling of shredded solid waste material involved the same record keeping as under the landfilling of conventional solid waste material along with these additional records.

The total tonnage received at the landfill was broken down into the tons shredded and the tons landfilled conventionally. The shredded material was landfilled separately from the conventional material and densities were calculated only for the shredded material compacted in the trench. The shredding drum rpm was recorded and the number of passes through the windrows. The time required for shredding, the time required to push the shredded material into the trench and compact it was also recorded. An additional job was added to the shredding operation and that was cleanup. The cleanup required a small rubber tired tractor and one or two men with broom rakes and shovels. At least once per week the drum had to be cleaned of rags and wire that had wrapped around the drum.

Fig. 5. Showing four sieves, sieve frame and collection bins.

Refuse Sieve

A refuse sieve was devised in order to determine the size distribution of refuse material. This apparatus is composed of metal frame, two collection bins, and four screens that will fit interchangeably into the frame. The screens are 18 x 24 inches and have effective openings of 7, 3-1/2, 1-1/2 and 3/4 inches, respectively, which determine the size categories for the refuse. The sieve was used to determine if size distribution has any significant effect on refuse density relationships.

Size Distribution

Visual inspection of shredded windrows does not provide an adequate indication of the effectiveness of a shredding mechanism. For this reason, a sieve analysis of windrow material was performed. Just like in soil or concrete analysis, size distribution of constituent materials has a great effect on the density of the final composite. The evaluation of size distribution and densities will enable one to determine the most effective method of operation. The sieve analysis was performed by the use of a set

of four screens whose effective opening were 7, 3-1/2, 1-1/2 and 3/4 inches, respectively.

Refuse Composition

The nature of refuse decomposition depends upon the materials which compose the refuse as well as other factors. Refuse samples analyzed for composition were placed in the following categories:

| PAPER | YARD TRIMMINGS | INERTS | GARBAGE |
|---|---|---|---|
| Paper | Grass and Leaves | Glass | Garbage |
| Rags | Hedge | Plastics | Fines |
| | Wood | Metal | |
| | | Ceramics | |

## CHAPTER V

## LANDFILLING COMPOSTED SOLID WASTE MATERIAL

A second proposed use for the Roto-Shredder is in a new method of composting municipal or residential refuse. Composting results in the aerobic decomposition of organic matter. It is not a new process for treating municipal or residential refuse; however, in the United States the method has never proven to be economically feasible. The previous methods of composting could not compete with conventional landfilling because of the high cost of equipment and facilities. Other composting methods have also had to rely on the sale of compost and salvaged material to supplement the cost of operation. The Roto-Shredder method of composting attempts to eliminate this requirement by landfilling all composted material.

The main purpose of the Roto-Shredder in composting is to:

1. Reduce particle size
2. Replace depleted oxygen.

In municipal refuse composting these are two important environmental requirements that can inhibit the biological process. As the windrow is turned the shredding action not only reduces the particle size by tearing, crushing, and breaking, but it also introduces air with its all important oxygen into all parts of the windrow and keeps the aerobic process operating.

### ASPECTS TO BE STUDIED

#### Densities and Refuse Categories

The composting study is similar in many respects to the shredding study. Densitites of the filled refuse are the primary consideration. The fact that not all refuse can be composted requires that the best method of operation for obtaining the maximum refuse density be found. This involves

the combination of composted and non-composted refuse in a manner similar to those of the shredded refuse study and can be determined in a like manner.

The Composting Operation

The composting study was to begin July 1971. The environmental factors to be observed were particle size, moisture content, aeration, hydrogen ion concentration, temperature, and initial carbon-nitrogen ratio as they influenced the activities of the organisms and therefore determine the speed and course of the composting cycle. Control of these factors during the composting cycle should enable maximum reduction of material in the shortest possible time.

Things of particular interest during composting include:

1. Finding the number of times the Roto-Shredder must pass through the windrow during the period to obtain the best results.
2. How much time will the refuse have to be composted in the windrows to deliver an economical reduction?
3. How much maintenance will be required of the windrows and the composting site. This involves maintaining a sufficient moisture content in the windrows, fly and rodent control, and general landfill appearance.

An area 200 x 300 feet was prepared for the composting operation. The top soil was stripped from this area and 6 inches of No. 2 stone was compacted and topped with 2 inches of fine screening material. The entire area was fenced with a 6 foot high wire fence. This area was constructed in September and October of 1970 before the winter months with the idea that our shredding

operation might have to be moved to the improved compost site. The actual composting evaluation of the Demonstration Project Grant was not to begin until July 1971. This was three months later than shown on the Monthly Progress Chart but the Project was three months late in starting.

Method of Evaluation

As in the two previous operations the weight of the material in the windrow would have to be recorded. The windrows would be of only selected material composed mostly of residential refuse. The experience gained through everyday working with the refuse haulers at the landfill site would dictate which refuse trucks would be selected for the buildup of windrows for composting and which refuse trucks would be sent directly to the working trench for disposal. The same procedure of record keeping as was employed for the conventional landfill and the shredded landfill would be used. The additional costs would be water used to maintain the mositure content in windrows, the use of a small rubber tired loader to combine windrows and pickup the compost, load it into a dump truck and haul it to the working trench for disposal.

## CHAPTER VI

## USE OF TEST CELLS FOR CONTROLLED MONITORING

In November 1970 Dr. Norman Sedlander, Professor of Civil Engineering, University of Toledo, and John R. Snell, President of John R. Snell Engineers, Inc., the Consultants for the Crawford County Project, met to review the progress of the Project thus far. Up to that time 2 inch plastic sample tubes were being installed in the daily landfill cells periodically from which leachate was pumped and a portable gas detector probe dropped down the sample tube to detect the presence of methane gas.

It was the feeling of both Dr. Sedlander and John Snell that merely to take samples of gas from the sampling plastic tubes and to make an estimate of the percentage of methane would give no real step forward for science. The other variables would be so great that the measurement of this variable would be virtually useless. The thought of not knowing whether all the gas was being monitored through the plastic tube or whether a great deal of it was getting away through the top cover would not be know. The thought was that a very true effort should be made to seal the top of some test cells by covering them with 30 to 36 inches of clay well-wetted and well-compacted in layers of 4 to 6 inches. To keep the top from drying out and cracking the suggestion was made to put 6 or 8 inches of sand over at least 30 inches of wetted thoroughly compacted clay. It was also suggested that at least every month additional moisture be added and a bulldozer pack the material down to make up for whatever settlement has taken place in the fill thus resealing any cracks that may have opened up.

It was recommended that the bottom of the sampling tube go into a hand dug sump. The sump would then be covered with a board and a drain

fixed to drain toward the sump so that leachate would tend to drain into the sump area. It was then recommended that the top of the sampling tube be tightly connnected to a standard household bellows-type dry gas meter. This meter should be read daily. A small gas sampling tube could be fed down into the larger sampling plastic tube so that a gas sample could be secured near the bottom. This gas could be drawn off periodically, say once every two weeks and analyzed in the laboratory for $CO_2$ and methane and the difference would be considered nitrogen. At the same time samples of leachate could be taken and analyzed for COD, BOD, pH, Total Solids and Voltile Solids, also Voltile acids. It would also be necessary to bring moisture content of the cell up to approximately 45 to 50 percent. Prior to adding water, a sample would be taken so it would be known what the initial water content was and the weight and from these knowns one could figure how many gallons of water would have to be added to bring this moisture content up to the desired figure. Six or nine cells would be constructed in this manner representing two or three cells each of raw material, shredded material and composted material. It was also suggested that nine or twelve bricks or blocks be placed or imbedded into the surface of the clay seal at points which would represent the area in a uniform manner and as time progressed level shots would be taken on these bricks and the average of these bricks would be taken to represent the settlement of the cell for that period.

In January 1971 an answer was received from the Project Officer on the proposed methods of relating digestive rates of the three solid waste processes as proposed. The Project Officer met with several people in the Division of Research and Development and Technical Operations. Two questions were asked:

1. Did the Solid Waste Office need detailed information relating to digestion rates of solid waste?
2. Would the method proposed result in valid, meaningful information relating to these digestion rates?

The answers given by the people in the Solid Waste Office was that valid information definitely was needed on the digestion rate of solid waste but that we would have to guarantee a valid approach concerning the absence or control of ground water ingress and egress. Gas production due to climatic differences that would result from landfilling raw refuse in the Fall, shredded refuse in the Winter and Spring, and composted refuse in the Spring and Summer, also, rain water ingress and temperature differences would make the result invalid. The only accepted approach to this problem was that the refuse would have to be enclosed in large containers over a short period of time under which adequate controls of all environmental conditions could be maintained. Gas, leachate and the physical settling of the cells would have to be monitored and analysed.

It was during the months of February and March 1971, that the idea of constructing air-tight test cells containing the three materials were discussed and details formulated. So it was at this time that the original timetable for shredding and composting of solid waste material was set aside and all efforts were devoted to the design, construction and monitoring of the test cells.

A meeting was called by the Project Director with the Consultants for the Project. At this meeting the methods of constructing test cells were discussed and many ideas were brought forth. After settling upon the use

of a 30 mil vinyl liner as the encasement material to construct air-tight test cells the method of construction was next discussed. It was decided to dig a trench 12 feet wide at the bottom, 18 feet wide at the top and 8 feet deep. An additional 2 foot of depth, 12 feet wide, would be dug so that 6 inches of pea gravel could be installed in the bottom over which 18 inches of compacted clay would be placed. A drain tile would be installed around the perimeter of the trench between the liner and the undistrubed earth to be used as an underdrain system to drain ground waters into a sump and also used as a monitoring well to check whether or not the liner was punctured and leachate migrating from the cells. Four trenches would be dug into the compacted clay bottom and 4 inches perforated plastic drain tile installed as a leachate collection system. The leachate would flow into an 18 x 4 inch vitrified sewer pipe cross with a concrete bottom and a vitrified top stopper sealed in the bell section. Two leachate sampling lines would be installed in this cross so that leachate could be pumped from either line. The reason for two lines is that if one would become plugged there would still be the second line from which leachate could be pumped from the sump. A gas sampling line would be installed high in the sump and brought out to the surface of the ground. Also, two additional gas lines would be installed at the 1/3 points in the cells. The three lines would be valved into a manifold and run into a wet gas recording meter. Tees would be placed in the lines and valved for gas sampling ports.

The six wet gas meters would be housed in a frost proof pit and above the pit would be a garage-type structure containing one large plastic bag holding the discharge from these meters so as to prevent contamination of the gas within each of the cells by the atmosphere.

A manual discharge from these bags would be accomplished through a low pressure check valve and exhausted to the outside.

It was decided that each cell would contain approximately 40 to 50 tons of residential refuse. This refuse would be compacted and covered with 6 inches of clay material. The leachate collection system would be cut off at the toe of the end slope of the cell and plugged. A new header collecting the ends of the cutoff leachate pipes would be installed and run into a new sump for the second cell construction. The cell was then covered with the vinyl cover sealed at the sides and at the bottom with a sealant supplied by the manufacturer of the vinyl liner.

The settlement monuments were to be concrete block set on top of the vinyl liner with a rod sticking through the 3 foot of cover material. Before taking a reading of the settlement monuments, a dozer would be used to compact the top 3 foot of cover material to eliminate any bridging effect that the vinyl liner might have so a true reading of cell settlement can be obtained. At this meeting it was decided to construct 6 cells, 2 cells of conventional material, 2 cells of shredded material and 2 cells of composted material. A total of six cells would take approximately 150 feet length of trench. Another addition to the cells would be a hose placed on top of the compacted refuse so that moisture could be added to the cells equal to the amount of rainfall that would penetrate the clay cover. This would be between 10 to 20 percent of the rainfall.

It was also decided to prepare 36 samples placed in plastic bags, 6 samples from each cell. It was decided that the size of sample from the conventional material a one cubic yard samples would be required and from the shredded and composted cells, 2 cubic foot sample bags would be sufficient. These bags would be tied so they would be air-tight and a

hose inserted in the bags so that moisture could be added in the same amount that was added to the test cells. A hole would be dug in the ground and one bag from each cell would be placed in a compartment. This compartment would be isolated by the use of plywood and backfilled with sand, then another compartment with one bag from each of the 6 cells would be constructed until 6 compartments containing one bag from each cell filled the hole. Then from time to time, say at an interval of a two month period one compartment would be dug out and the material in the six bags examined to give an indication of the biological action going on in the test cells as to the degree of decomposition. Lechate and gas would not be tested for the bags would be punched full of holes.

The following are the analysis to be run on the landfilled material, leachate and gas giving the frequency of testing and the location of testing.

## CHEMICAL TESTS TO BE RUN

| | |
|---|---|
| I SOLIDS ANALYSIS (On Representative Samples) | EVERY 2 MONTHS<br>VOLUME MONTHLY<br>LOCATION FOR ANALYSIS WORK |
| 1. % MOISTURE | Laboratory in Trailer at Landfill |
| 2. % DRY SOLIDS | Laboratory in Trailer at Landfill |
| 3. % VOLATILE SOLIDS | Laboratory in Trailer at Landfill |
| 4. CELLULOSE | Laboratory at University of Toledo |
| 5. REFUSE COMPOSITION | Laboratory in Trailer at Landfill |
| 6. SIZE DISTRIBUTION | Laboratory in Trailer at Landfill |
| 7. CARBON-NITROGEN RATIO | Laboratory in Trailer at Landfill |
| II LEACHATE ANALYSIS | EVERY WEEK<br>VOLUME WEEKLY<br>LOCATION FOR ANALYSIS WORK |
| 1. TEMPERATURE | On Sight |
| 2. pH | Laboratory in Trailer at Landfill |
| 3. BOD | Laboratory at University of Toledo |
| 4. COD | Laboratory in Trailer at Landfill |
| 5. TOTAL, DISSOLVED & VOLATILE SOLIDS | Laboratory in Trailer at Landfill |

| | | |
|---|---|---|
| 6. | NIGROGEN - NITRATE & AMMONIA | Laboratory in Trailer at Landfill |
| 7. | PHOSPHATE - TOTAL & ORTHO | Laboratory in Trailer at Landfill |
| 8. | VOLATILE ACIDS | Laboratory in Trailer at Landfill |
| 9. | SPECIFIC CONDUCTANCE | Laboratory in Trailer at Landfill |
| 10. | CHLORIDES | Laboratory in Trailer at Landfill |
| 11. | ALKALINITY | Laboratory in Trailer at Landfill |
| III | GAS ANALYSIS | WEEKLY<br>VOLUME DAILY |
| 1. | $CO_2$ | ALL GAS ANALYSIS TO BE DONE |
| 2. | $CH_4$ | at The University of Toledo |
| 3. | $O_2$ | |
| 4. | $N_2$ | |
| 5. | $H_2S$ | |
| 6. | CO | |

After this meeting drawings were prepared and the methods and procedures written in a report and a meeting arranged with the Division of Demonstration Operation, Bureau of Solid Waste Management, in Cincinnati. The results of this meeting are shown in Appendix C of this report along with the drawings of the original layout of the test cells.

Before the construction of the test cells could begin, the project had to be approved by the State of Ohio Department of Health, Solid Waste Division. On February 22, 1971, detailed plans for the Supplemental Proposal to the Crawford County Sanitary Landfill to construct and operate the test cells were submitted to the Ohio State Department of Health for their approval. On March 4, 1971, the approval was given, the letter of approval is included in Appendix C.

By this time in the Project the laboratory equipment had been ordered and much of it had been delivered and set up in the trailer used as a mobile laboratory. Additional laboratory equipment had to be ordered to monitor the test cells such as: Six wet-type gas meters, temperature probes, thermistor, moisture balance and a mercurial barometer. A

number of plastic liner fabricators were contacted and given the specifications for our project. The most important specification was that the vinyl liner must resist alkalines and acids created by the decomposition of the material in the cell. The contract for fabricating the 30 mil vinyl liner was given to a fabricator in Findlay, Ohio. Two sheets of vinyl were fabricated, one sheet was 50 feet wide and 150 feet long which was used to line the trench. The second sheet was 30 feet wide and 200 feet long which was to be cut in desired lengths as the cover sheet for the individual cells. A delivery schedule was then worked out with the fabricator.

A contractor was next engaged to dig the trench and to install all of the necessary underdrains, sumps, placing and compacting of the refuse and placing the final 3 foot of the clay cover. The installation of the 6 test cells was done with contracted labor under the guidance of the Project Director and his assistants. It was not the intention to interfere with the normal operation of the County Landfill by using the County Landfill personnel or equipment.

A proposed daily schedule for the installation of the test cells was prepared as follows:

| | PROPOSED TEST CELL INSTALLATION SCHEDULE | ACTUAL TEST CELL INSTALLATION SCHEDULE |
|---|---|---|
| Mon. 4-12-71 | Place 30 tons of refuse out for composting | Placed 35.83 tons of refuse in windrow for composting. Windrow was shredded twice |
| Tues. 4-13-71 | Start digging Test Cell trench | Trench almost completed |
| Wed. 4-14-71 | Finish trench and begin installing underdrain | Trench is ready to be lined with vinyl. Windrow shredded for 3rd time |

| | PROPOSED TEST CELL INSTALLATION SCHEDULE | ACTUAL TEST CELL INSTALLATION SCHEDULE |
|---|---|---|
| Thur. 4-15-71 | Finish underdrain, install vinyl liner and place Second 30 tons of refuse in windrow for composting | Placed 28.5 tons of refuse in windrow for composting. Windrows shredded twice Vinyl liner placed in trench with pea gravel |
| Fri. 4-16-71 | Install gravel underdrain on liner, place 18" of compacted clay over gravel and start refuse underdrains | Trench was prepared for filling on Monday |
| Mon. 4-19-71 | Finish underdrains and place 30 tons of conventional refuse in Cell #1, install gas hose and temperature probe | First windrow was shredded for the 4th time, second windrow was shredded for the third time. Placed 29.3 tons in trench, Cell #1 |
| Tues. 4-20-71 | Run cell refuse underdrains and compact clay underdrains | Finished filling trench |
| Wed. 4-21-71 | Cover refuse with clay, install water hose for adding moisture and vinyl cover, make side seams | Cell #1 was sealed |
| Thur. 4-22-71 | Prepare trench for Cell #2 install gas hose and temperature probe. Place 23 tons of refuse in cell | Placed 29.1 tons of refuse in trench. Windrow #1 was shredded the 5th time. Windrow #2 was shredded for the 4th time |
| Fri. 4-23-71 | Finish placing 30 tons of refuse in cell. Install refuse underdrain to sump and pipe to compacted clay underdrain. Cover refuse with clay | Cell #2 was filled. Gas hose and temperature probe were installed |
| Mon. 4-26-71 | Install hose for adding moisture, install vinyl cover, shred 30 tons of refuse | Cell #2 was sealed. 32.4 tons of refuse were shredded twice and placed in trench |
| Tues. 4-27-71 | Place 30 tons of shredded material in cell, install gas hose and temperature probe | Finished placing the shredded refuse in cell |

| | PROPOSED TEST CELL INSTALLATION SCHEDULE | ACTUAL TEST CELL INSTALLATION SCHEDULE |
|---|---|---|
| Wed. 4-28-71 | Place 30 tons of shredded refuse in cell and compact, connect refuse underdrain to sump, install compacted clay underdrain | Windrow #1 shredded 6th time<br>Windrow #2 shredded 5th time<br>Cell #3 was sealed |
| Thur. 4-29-71 | Install moisture hose, cover with vinyl, shred 30 tons of refuse | Shredded 29.9 tons of refuse six times for Cell #4 |
| Fri. 4-30-71 | Place 30 tons of refuse in cell | Cell #4 was filled<br>Windrow #1 shredded 7th time<br>Windrow #2 shredded 6th time |
| Mon. 5- 3-71 | Connect refuse underdrain to sump, install compacted clay underdrain, cover refuse with vinyl | Cell #4 sealed |
| Tues. 5- 4-71 | Finish building sumps | Prepared to fill Cell #5<br>Sump was built |
| Wed. 5- 5-71 | Place cover (3 Ft.) over completed cells with monuments | Cell #5 was made ready to fill. 4000 gal. of water were sprayed on the windrows |
| *Thur. 5- 6-71 | Place windrow #2, the composted material in Cell #5 | 3.1 inches of rain fell overnight. Trench was flooded with $3\frac{1}{2}$ feet of water in it. Shredding area was under 1 to 2 inches of water. No work could be done on the cell or windrows |
| Fri. 5- 7-71 | Install refuse underdrains and compacted clay sump pipe, cover refuse with clay. | First $3\frac{1}{2}$ cells sealed with dirt and monuments were placed.<br>Windrow #1 shredded 8 & 9th time<br>Windrow #2 shredded 7 & 8th time<br>Rained 0.5 inch in the evening |
| Mon. 5-10-71 | Install hose and vinyl liner | Pumped water out of trench<br>Filled Cell #5 with windrow #1 |

* The four installed test cells were flooded and original analysis parameters of the project changed.

| | PROPOSED TEST CELL INSTALLATION SCHEDULE | ACTUAL TEST CELL INSTALLATION SCHEDULE |
|---|---|---|
| Tues. 5-11-71 | Finish cell cover and grade area | Connected leachate underdrains to sump for Cell #5<br>Installed gas meter building foundation base |
| Wed. 5-12-71 | Nothing scheduled | 0.6 inch rain overnight<br>Pumped water out of trench<br>Windrow #2 shredded 9th time |
| Thur. 5-13-71 | Assemble metal building | Extended gas, water and temperature probe lines for Cells #1, 2, 3 & 4 to gas meter building<br>Installed gas meters for Cells #1, 2, 3 & 4 |
| Fri. 5-14-71 | Final connections and prepare for final cell | Finished connecting meters to the lines |
| Mon. 5-17-71 | Nothing scheduled | Picked up loose papers in shredding area |
| Tues. 5-18-71 | Nothing scheduled | Started running a Power line to the trench area |
| Wed. 5-19-71 | Nothing scheduled | Worked on Power line |
| Thur. 5-20-71 | Nothing scheduled | Finished Power line |
| Fri. 5-21-71 | Nothing scheduled<br>Final check of trench for last cell | Everything was ready for Cell #6 |
| Mon. 5-24-71 | Place 6 week composted refuse in trench | The week was spent getting the lab on the site set-up for leachate analysis |
| Tues. 5-25-71 | Connect refuse underdrains to sump, install compacted clay underdrain, cover compost | |
| Wed. 5-26-71 | Install moisture hose and vinyl cover | |
| Thur. 5-27-71 | Final grading | Windrow #2 shredded 11th time |
| Fri. 5-28-71 | Final hook-ups and connections | |

| | PROPOSED TEST CELL INSTALLATION SCHEDULE | ACTUAL TEST CELL INSTALLATION SCHEDULE |
|---|---|---|
| Tues. 6- 1-71 | | Windrow #2 shredded 12th time |
| Wed. 6- 2-71 | | Worked in lab on samples of leachate |
| Thur. 6- 3-71 | | Worked in lab on samples of leachate |
| Fri. 6- 4-71 | | Windrow #2 shredded 13th time |
| Mon. 6- 7-71 | | Started building gates for shredding area |
| Tues. 6- 8-71 | | Windrow #2 shredded 14th time |
| Wed. 6- 9-71 | | Extra piece of vinyl was attached and sealed |
| Thur. 6-10-71 | | Cell #6 was filled. Gas hose, water hose and underdrain were each hooked up. Pits for sample bags and leachate from compost area were dug |
| Fri. 6-11-71 | | A suction hose for water, from the creek to the composting area, was started. Drain pipes in compost area were installed |
| Mon. 6-14-71 | | Cell #6 was flooded. Gates for shredding area were placed in openings |
| Tues. 6-15-71 | | Worked on water line to creek |
| Wed. 6-16-71 | | Sample bags were placed in pit and covered<br>Finished water line to creek |
| Thur. 6-17-71 | | Put up a Power line to the pump at the creek |
| Fri. 6-18-71 | | Cleaned shredding area and area around the cells |

It is of interest to note that the schedule was adhered to quite closely until the day of May 6, 1971. The night before 3.1 inches of rain fell during the night, flooding the already installed trenches and the entire composting and working area. This changed the scope of the entire project because one of the parameters insisted on by the Office of Solid Waste could no longer be evaluated. This parameter was the control of moisture entering the test cell. The analysis of the cells were to be started under dry conditions. A total of 144 representative samples of known weight of the refuse in the 6 cells were bagged in plastic bags which were to be dried to the dry weight of the refuse in the cells could be calculated. It was during this time the Project Director was attending a Symposium on Solid Waste Demonstration Projects given by the U.S. Environmental Agency, Solid Waste Management Office on May 4, 5 and 6 in Cincinnati, Ohio. This is not to say that if the Project Director had been on the Project the water entering the cells would have been prevented but according to the proposed installation schedule on May 5 the schedule of operation was placing 3 foot of cover over the completed cells. The 3 foot of cover was to serve as the absolute sealer cover for the cells to prevent the egress of gas and the ingress of ground waters into the cells. To rid the area of the standing water, pumps were brought in and the water pumped away into the drainage areas. The cells were pumped and the water wasted. If someone had thought of pumping the cell water into containers to hold for analysis and measurement, this project could have been salvaged with most of the original objectives achieved. Cells 5 and 6 which contained the composted material were constructed much later than originally scheduled. The original schedule was for cell 5 to be constructed after four weeks of composting and cell 6 after six weeks of composting. These

cells were also flooded after installation with the idea that all six cells would be started off under the same conditions.

After many discussions with the people in Demonstration Grants and Research and Development, the Office of Solid Waste in Cincinnati, the order was given that the Project would be terminated after the first year which was June 30, 1971.

Test Cell Comparison and Studies

The following Tables and Charts are the data collected and recorded for the test cells from the day each cell was constructed until the end of the Project of June 30, 1971.

Tables VI-1 through VI-6 in Appendix D classify the refuse in each of the 6 cells into eight categories. Four samples totaling at least 300 pounds were broken down into the eight categories and the mean average percentage of the eight categories is recorded at the bottom of each Table. From the average percentages given at the bottom of the Tables the indication is that each cell contains about the same solid waste material.

Tables VI-7 and VI-8 in Appendix D are the recorded readings of the wet gas meters. Although the wet gas meters were not connected to the gas tubes immediately after cell construction the ends of the gas tubes were plugged to contain the gas in the cell. The first gas readings are of the gas retained in the cells. We were never able to run a gas sample analysis; all that is recorded is the quantity of gas produced while the cells were still in an anaerobic condition. The points on Charts 1 and 2 are of the same daily gas readings as shown in Tables VI-7 and VI-8 all in Appendix D. From the Charts it can be observed that sometimes a negative pressure is created within the cell. It is disappointing that at these particular days the barometer was delivered with a broken mercury tube so barometric readings

were not recorded during the corresponding days of negative pressure. The initial gas meter reading as shown is the reading that was already recorded on gas meter dial so this reading would have to be subtracted from all the gas meter readings to bring the starting point down to zero on the gas meter scale.

Charts 3, 4 and 5 in Appendix D are of the recorded temperatures within the cells. A temperature probe was placed in the middle of each cell and the termistor thermometer used to record the temperature reading. Cells 1, 2, 3 and 4 all show a rise in temperature after the material was placed in the cell and covered with 6 inches of clay and the plastic covering. These cells were all in an aerobic condition during this time. There does not seem to be any pattern as to whether the aerobic condition in the cell is maintained longer with landfilled conventional refuse or landfilled shredded refuse. The 2 composted cells immediately dropped in temperature which indicates that the cells did not go through the aerobic condition, but were influenced by the ground temperature.

Tables VI-9, VI-10, VI-11, VI-12, VI-13, and VI-14 in Appendix D are of leachate sample analysis for the 6 cells. It is difficult to draw any conclusions as to the analysis of leachate for such a short sampling period of only one month. In Appendix E of this report two leachate samples were pumped from the cell sumps during the year of 1972. From these leachate sample analysis a little more definite conclusion can be drawn as to action between the water in the cells and the refuse. For example, Cells 1, 2, 3 and 4 are still high in BOD and COD and Cells 5 and 6 are quite low in BOD and COD. Appendix E contains some additional readings of cell temperatures and wet gas meter readings which were taken after the termination of the Project.

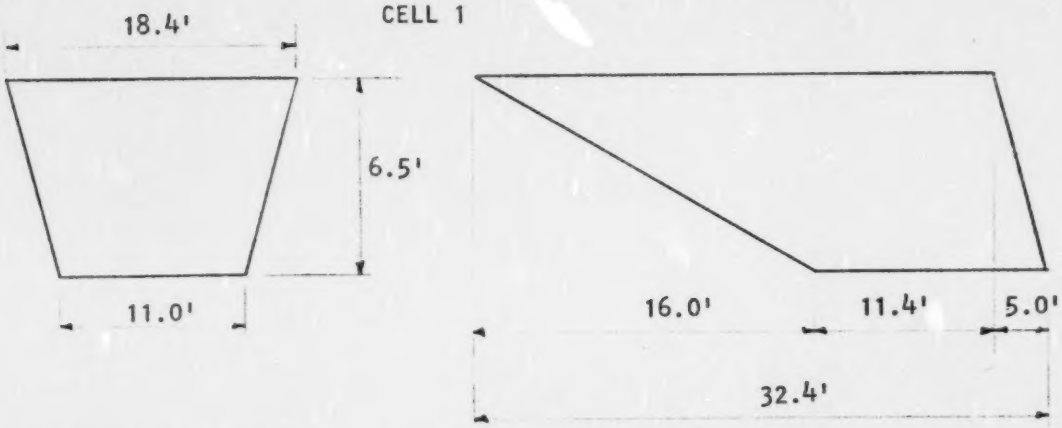
Table VI-15 in Appendix D, Settlement Monument Readings, were again not very conclusive because we only have two readings. The initial monument reading and a reading three weeks later which indicated the cells did settle somewhat.

Figures VI-1, VI-2 and VI-3 depict the configuration of the trench used for each cell, the tons of material compacted in the cell and the densities achieved for each cell. Figures 6 through 21 are actual photographs of the cell construction, the compacted refuse in the cells, the gas and temperature monitoring system and the metal enclosure building for the wet gas meters.

FIGURE VI-1

CELL DENSITIES

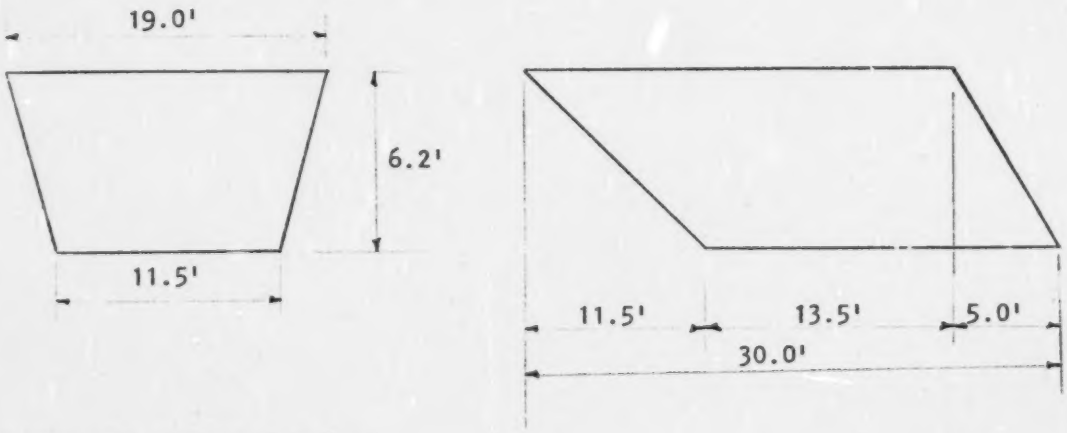
CELL 1




WEIGHT 29.3 Tons of Refuse

DENSITY 0.407 Ton/yd.$^3$

CELL 2



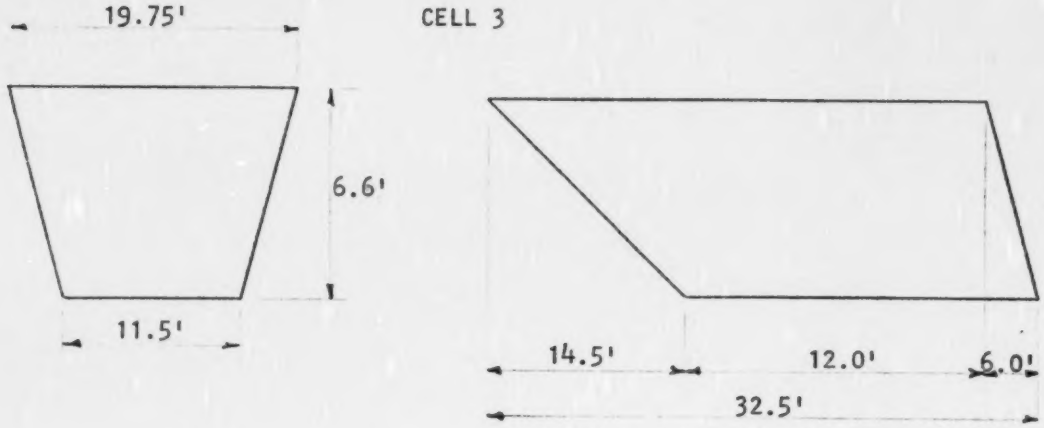

WEIGHT 29.1 Tons of Refuse

DENSITY 0.400 Ton/yd.$^3$

FIGURE VI-2

CELL DENSITIES

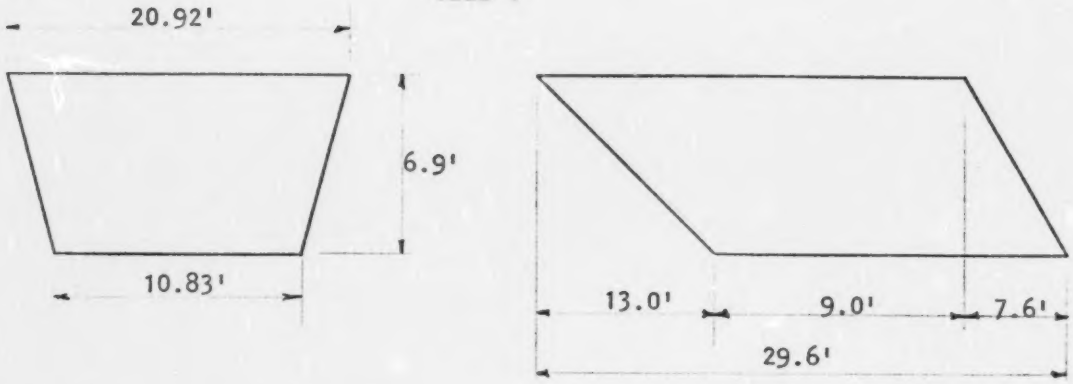
CELL 3




WEIGHT 32.4 Tons of Refuse

DENSITY 0.381 Ton/yd.$^3$

CELL 4



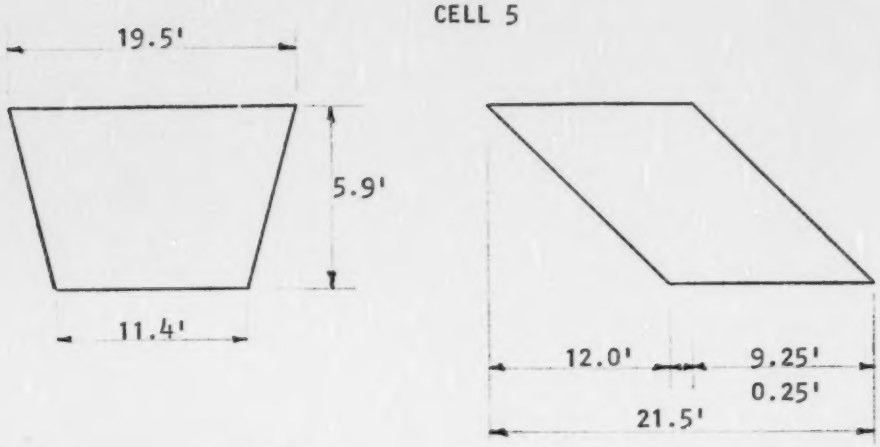

WEIGHT 29.9 Tons of Refuse

DENSITY 0.382 Ton/yd.$^3$

FIGURE VI-3

CELL DENSITIES

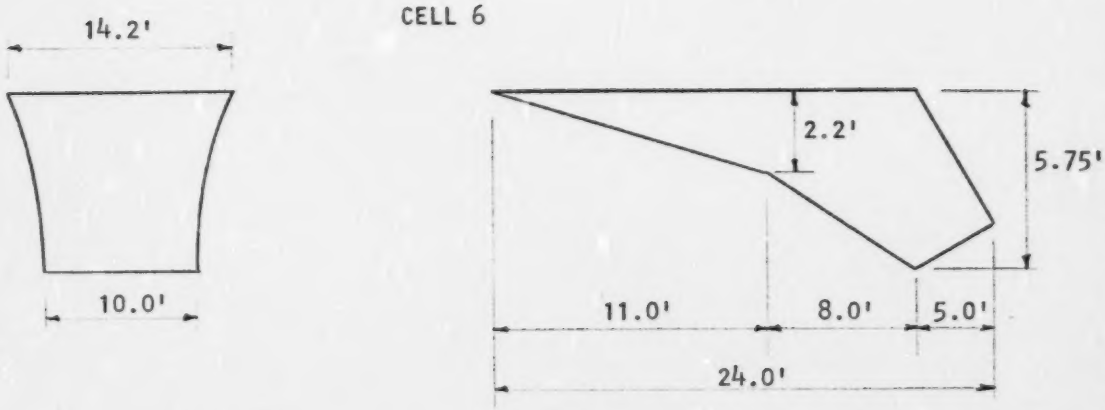
CELL 5




WEIGHT 35.83 Tons of Refuse

DENSITY 0.998 Ton/yd.$^3$

CELL 6




WEIGHT 28.5 Tons of Refuse

DENSITY 1.31 Tons/yd.$^3$

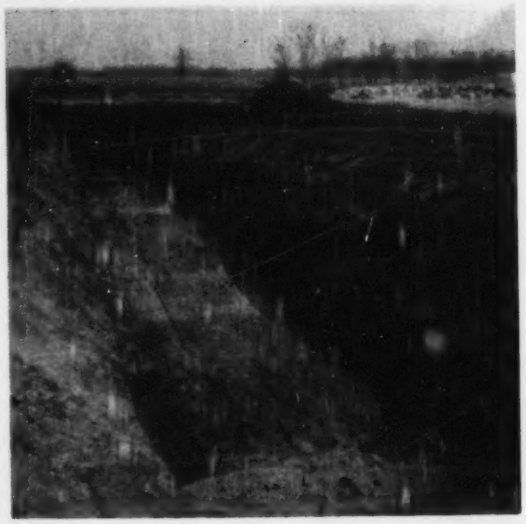


Fig. 6. Dug trench with plastic tile underdrain ready for liner.

Fig. 7. Liner installed.

Fig. 8. Compacting 18" of clay in bottom with 6" of pea gravel under clay.

Fig. 9. Perforated plastic tile leachate collection system.

Fig. 10. 3/16" plywood side protection larger hose gas line and smaller hose protection for temperature probe wire.

Fig. 11. Method used to fill all test cells. Two truck loads loaded from refuse on ground and one loader bucket full spread in trench run over 20 times with loader.

Fig. 12. Cell #1 compacted with hose to add moisture.

Fig. 13. Cell #1 covered with clay, leachate pipes being cut off and header run to sump.

Fig. 14. Plastic liner covering Cell #1. Side seams are sealed with solvent.

Fig. 15. Roto-Shredder shredding Cell #3 refuse.

Fig. 16. Shredded refuse compacted in Cell #3, Cell #2 plastic cover showing.

Fig. 17. Roto-Shredder completing turning compost for Cells #5 and #6.

Fig. 18. Cell #5 with composted refuse.

Fig. 19. Roto-Shredder turning Cell #6 composted refuse before landfilling.

Fig. 20. Running gas, water and electrical lines to metal building enclosure, leachate sump with temporary cover.

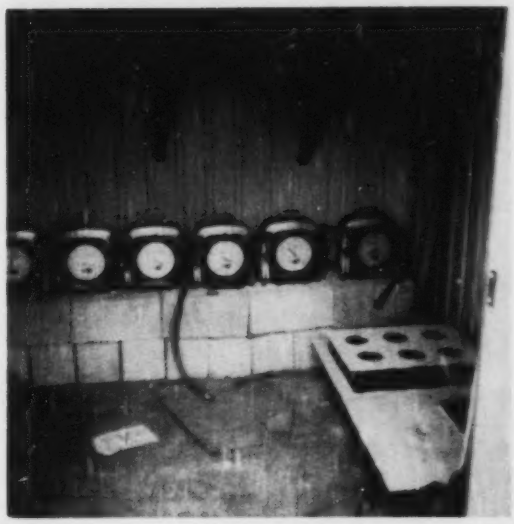


Fig. 21. Six wet gas meters installed in metal building, water hoses for addition of moisture shown.

# CHAPTER VII

# LABORATORY INVESTIGATION

A possibly valuable aspect resulting from the treatment of refuse before landfilling, is the reduction of potentially dangerous pollutants which result from anaerobic decomposition and leaching of this material. The limited usefulness of previously used landfill areas and the possibility of leachate contamination of ground and surface waters have been overlooked in the past but are now becoming serious ecological considerations. The principal objective of the laboratory investigation is to compare the decomposition of three types of landfilled material to determine whether some methods for the pretreatment of refuse can effectively limit pollution. To determine this, leachate, gas and refuse samples would have to be analyzed for various characteristics which would best serve as indicators of a general change in the decomposition processes. The program for the year 1971 involved primarily the establishment of sampling and testing procedures, equipping and arranging the laboratory, and preparing controlled test cells for evaluations. Some preliminary investigation was also done on leachate and refuse samples taken from the conventional landfill trenches to test the equipment and proposed methods of analysis. The progress of these investigations to date and the various phases of this program are recorded in the following sections.

## FACILITIES AND EQUIPMENT

### Laboratory

The laboratory was housed in a mobile trailer located near the landfill office building. It was fully equipped to perform all the proposed analysis except for a BOD incubator and a gas chromatograph. See Table VII-1.

TABLE VII-1

LABORATORY EQUIPMENT

| | ITEM | MANUFACTURER | MODEL NO. |
|---|---|---|---|
| 1. | pH Meter | Fisher | 120 |
| 2. | Thermistor Thermometer | Bachrach | 12-7003 |
| 3. | Drying Oven | Boekl | 1064 |
| 4. | Muffle Furnace | Thermolyne | F-01500 |
| 5. | Balance | Ohaus | 1600 |
| 6. | Colorimeter-Spectronic 20 | Bausch & Lomb | 33-29-95-01 |
| 7. | Water Still | Barnstead | A 1013 |
| 8. | Portable Water Laboratory | Hach | Dr-El |
| 9. | Mositure Balance | Ohaus | 6010 |
| 10. | Mercurial Barometer | Fisher | 2-383 |

Determination of these remaining characteristics prohibited by exclusion of this equipment was to be performed at the University of Toledo Sanitary Engineering Laboratory.

Fig. 22. Mobile trailer used as field laboratory.

Combustible Gas Detector

A Unico portable gas detector was to be used to detect the presence of methane gas in the test cells and trenches. This device will be used to determine frequent on site concentrations of methane and enable detection of significant changes so that further investigation can be carried out on more sophisticated equipment. It would also provide an effective safety mechanism for the detection of methane on the landfill site which may be hazardous to the welfare of the people working there.

TRENCH SAMPLING AND TEST CELLS

Trench Samples

During the filling of the conventional landfill trenches, leachate and gas collection tubes were placed throughout the cells to enable collection of these products after decomposition has taken place. These

tubes were connected to a plastic pipe that served as a well from which the gas or leachate can be taken by means of a portable pump. These grab samples were used as a comparison to the data obtained from the 6 test cells.

GAS ANALYSIS

Various gases have long been associated with the decomposition of solid organic material. Namely: Carbon dioxide, methane, nitrogen, oxygen, hydrogen and hydrogen sulfide. These are the gases which will determined when gas samples were collected from the test cells. Gas samples were analyzed at the University of Toledo using a gas cromatograph with a digital readout system. Carbon monoxide (CO) was determined since the capability was readily available and since it is sometimes an indication of an incomplete conbustion process.

The gases which are most prevalent and of primary concern are carbon dioxide and methane. The following empirical formula which represents decomposable refuse as present by Gram (1) and the following equations will indicate why.

Decomposable Refuse = $C\ H_a\ O_b\ N_c$

Under aerobic conditions decomposition progresses as:

$$C\ H_a\ O_b\ N_c + 1/4\ (4+a-2b-3c)O_2 \rightarrow C\ O_2 + 1/2\ (a-3)\ H_2O + cN\ H_3$$

After the available oxygen is utilized and anaerobic decomposition takes over, the reaction is:

$$C\ H_a\ O_b\ N_c + 1/4\ (4-a-2b+3c)\ H_2O \rightarrow 1/8\ (4-a+2b+3c)\ C\ O_2 + 1/8\ (4+a-2b-3c)\ C\ H_4 + cN\ H_3$$

As is shown in these equations, the carbon dioxide and methane are the primary gaseous products of the decomposition processes. Since the decomposition becomes anaerobic when the initial oxygen is utilized and

the cell is sealed off from the atmosphere, methane becomes a primary indication that the anaerobic processes have taken over.

Two distinct processes occur during the anerobic decomposition process; carbohydrates are broken down to organic acids by the acid forming bacteria, and these acids then become food for the methane forming bacteria who convert them to carbon dioxide and methane. The nitrogen becomes a part of the living cells and are cycled through successive generations of micro-organisms. The quantity of available nitrogen increases slowly as proteins are broken down.

Hydrogen and oxygen can be released through minor reactions in minor quantities. Hydrogen sulfied can be released if there is sulfur present either in the waste or the ground water which may enter the cell, but this also will be minor quantities.

SOLIDS ANALYSIS

Since the material in the fill has such a definite effect on the other factors being evaluated, leachate and gas, specific characteristics of the solid material will be analysed so that specific changes in the other factors can be better explained. The three types of material to be considered are:

1. Ordinary unshredded residential refuse.
2. Pre-shredded refuse using a Cobey Roto-Shredder.
3. Pre-shredded and pre-composted residential refuse using a Cobey Roto-Shredder in the windrow method.

It is anticipated that the residential refuse can be controlled so that all samples will be as close to being uniform as possible before the pre-treatment procedures begin. It is also anticipated that samples of the decomposing refuse can be analyzed at specific periods of time. The

characteristics proposed for the evaluation and explanations of each follow.

Percent Moisture and Percent Dry Solids

In solid waste decomposition, whether aerobic or anaerobic, the moisture content of the material significantly effects the biological activity which performs the process. Changes in moisture can cause changes in decomposition rates and can also change the nature of the process itself. Under control conditions this fact necessitates that moisture content be a control aspect. Percent moisture is the percent of the total sample that is water, the remaining percent is percent dry solids.

Percent Volatile Solids and Percent Ash

The volatile solids represents the combustible matter in the sample and the noncombustible is represented by the ash. It is generally assumed that this combustible matter is primarily organic in nature and is capable of being decomposed by micro-organisms. By determining volatile solids and ash content, one can estimate the amount of decomposition taking place.

Carbon-Nitrogen Ratio

A decline in the C/N ratio represents the decomposition of organic material because carbon is lost in the form of carbon dioxide. Sometimes a loss in nitrogen also occurs; therefore, it is necessary to determine both quantities so that a true picture can be seen. The carbon-nitrogen ratio is also used to determine the suitability of a compost for use on agricultrual soils.

Cellulose

Paper is a dominant material in residential and commercial refuse and the basic substance of all paper products is cellulose. About 80 to 90 percent of the cellulose present in raw refuse can be broken down by

composting and its proportion to the total decomposable substances is relatively high. By knowing the decomposition rate of cellulose, it may be possible to determine optimum compost time.

LEACHATE ANALYSIS

Refuse leachate is a product of the solution of a component from a solid mixture by a liquid solvent, where the liquid in this situation is water and the solid is the entire mass of refuse within the cell. Water enters a landfill in a number of ways:

1. Water applied to the surface and percolated vertically through the soil cover.
2. Water from an adjacent source moving horizontally through the side of the fill.
3. Water entering from the bottom of the fill due to a rise in the ground water table or capillary action.
4. Water being present in the fill site prior to or during placement of refuse material.

The necessary condition for impairment of water outside the limits of the refuse cell however, is the supersaturation of those portions of the fill in contact with the water.

The composition of leachates varies due to several factors:

1. Material in the fill (organic, inorganic, degradeable, nondegradeable, soluble, insoluble).
2. Conditions in the fill (temperature, pH, moisture content, age of fill).
3. Characteristics of incoming solvent water.
4. Surrounding soil characteristics.

In the testings of leachate from the control test cells, the primary influence to be considered is the material in the fill. All other factors were controlled or monitored. Characteristics of leachates were chosen and descriptions of each are given. A Table showing results of previous leachate analysis using some of these characteristics also follows.

## CHARACTERISTICS

### pH

The pH value of a solution is the logarithm of the reciprocal of its hydrogen ion activity. It is most valuable in leachate analysis as an indication of the activity of the anaerobic bacteria which decompose the waste material. The intermediate products of anaerobic decomposition are the organic acids which the methane formers use as food to complete the process. If the amount of acid produced is too great and the pH drops too far, the methane forming bacteria will die and the process will remain incomplete. The pH value, then, indicates how well the process is operating.

### Specific Conductance

Specific conductance or conductivity gives a measure of the resistivity of the ionized material in water. By knowing the total concentration of dissolved ions, ground water can be easily compared. Specific ions cannot be determined by this method but marked quality changes can easily be determined throughout the landfill.

### Chlorides

The chloride ion concentration is used as a measure of pollution since it is a universally soluable and stable ion. It is valuable for measuring leaching from a refuse site because it is easy to measure, is not readily absorbed by soil formation, is not altered by biological process and considerable quantities may be present in refuse.

5-Day BOD

Biochemical Oxygen Demand is a measure of the amount of oxygen needed by the micro-organisms present to oxide the organic matter in the sample. Due to the concentrated nature of leachate, high dilution ratios are needed for determination. This limits the accuracy of the results but also indicates the strength of leachate as compared to other pollutants such as sewage effluent.

COD

Chemical Oxygen Demand indicates the total amount of oxidizable material in the sample, primarily, organic matter. Like BOD it has to be determined by the use of heavy dilution and accurate results are difficult to obtain. An advantage of using COD as a parameter is that the biological interferences which cause errors in BOD have little or no effect on it.

Solids

The determination of the various aspects of solids concentration: Total, dissolved, suspended and volatile are a physical indication of changes in composition of the leachate and the refuse in the cell. Some of the solids can be eliminated by filtration if the soil characteristics are favorable but one of the most serious contaminants of ground water that can be associated with leachate is the increase in dissolved solids concentration which occurs because a high enough dilution factor is not available.

Phosphate - Total and Ortho

In recent years phosphate has been considered as the principal factor influencing the eutrophication problem, and phosphate control is being made a mandatory part of waste treatment. This necessitates the determination of phosphate in leachate and its possible effect on surface waters.

Nitrogen - Nitrate and Ammonia

Under anaerobic conditions nitrates are reduced to nitrites which may be reduced further to ammonia or nitrogen gas. By determining these two characteristics, they can be used as an indication of how the anaerobic reaction is progressing.

Temperature

Temperature is an important factor affecting the rate of any biological reaction, it is also measured to determine the effect of ground temperatures on refuse cell temperatures.

Volatile Acids

Volatile or organic acids are a result of the intermediate stages of anaerobic decomposition. By knowing the volatile acid concentration, the pH variation can be better explained.

Alkalinity

Alkalinity may be defined as the capacity for neutralizing acid and is usually due to the presence of bicarbonate and carbonate ions in natural water. It can be an indication of where the moisture in the refuse area predominately comes from, percolation or ground water seepage.

See Appendix F for laboratory procedures.

## CHAPTER VIII

## CONCLUSIONS

It is rather difficult to draw any definite conclusions from this short term Grant Application Project.

The only objective of the three original objectives of the Grant Application carried to completion was the cost analysis of operating the Crawford County Sanitary Landfill.

The shredding objective was interrupted by adverse weather conditions during January and February, the construction of the test cells and the termination of the Project after the first year.

Landfilling of composted material on a day-to-day operation was never started even though the composting area was prepared. From data accumulated during the composting of refuse for the test cells a conclusion was made that it would require four acres of land to compost 500 tons of refuse per day. The additional cost of water, turning the windrows, combining the windrows, loading the compost into trucks and hauling to the landfill working face were never determined.

Even though the original objectives of the test cells were spoiled by flooding of the cells it was always the feeling of the Project Director that valuable information such as the decomposition of solid waste material in trenches could still be recorded to serve as guidelines for design of future landfill operations. To be able to start all 6 test cells off with the knowledge of the dry weight of the material in the cell and then be able to determine the gallons of water required to produce leachate in the cells along with a record of other parameters such as tempterature, gas production and settlement would have been the fulfillment of the objectives

and goals set by the Office of Solid Waste but it is still felt that a lot of valuable information could have been recorded on the decomposition of the material in the cells after they had been flooded. A comparison of the initial leachate analysis and analysis that was done some eighteen months later indicates a great change in the cells. We find that the shredded material and conventional material are still very high in BOD, COD, Total Solids, Alkalinity, Volatile acids and chlorides, while in the composted cells the BOD and COD have dropped to a low level with the Total Solids dropping along with Volatile solids and acids. The color of the leachate is very clear coming from cells #5 and #6 while from #1, #2, #3 and #4 they are still very dark and have a septic odor.

The results of sample analysis from the test cells on this Project resulted in the belief that the processing of solid waste biologically in a windrow before landfilling is one of the better methods of landfilling today. Not only is the material safe to landfill but there is a definite savings in land, as much as two to two-one-half times, over the conventional method of landfilling. Shredding of the material by the Roto-Shredder as a means of saving land does not accomplish this objective using density as a comparison. Shredding of residential and commercial material does not increase density but does save in compaction time.

The construction of the test cells as shown in Appendix D did result in air-tight cells as evidenced by a vacuum being created when leachate was pumped from the cells. Further work with these cells by pumping the leachate into a holding basin, causing atmospheric air to be sucked in through the gas hose and then pumping the leachate back into the cell could begin a method of aerobic decomposition of the waste in the cells to hasten cell stabilization.

Another phenomenon which keeps occurring in the leachate sumps for cells #1, #2, #3 and #4 is the consistent buildup of foam which fills the sump. This foam appeared to be very light and fluffy and tends to blow out when the sump covers are removed. Further investigation of the causes for foaming and the chemical action taking place could be additional scientific study of the test cells.

A listing of General References on methods of sanitary landfill operation is included in Appendix G.

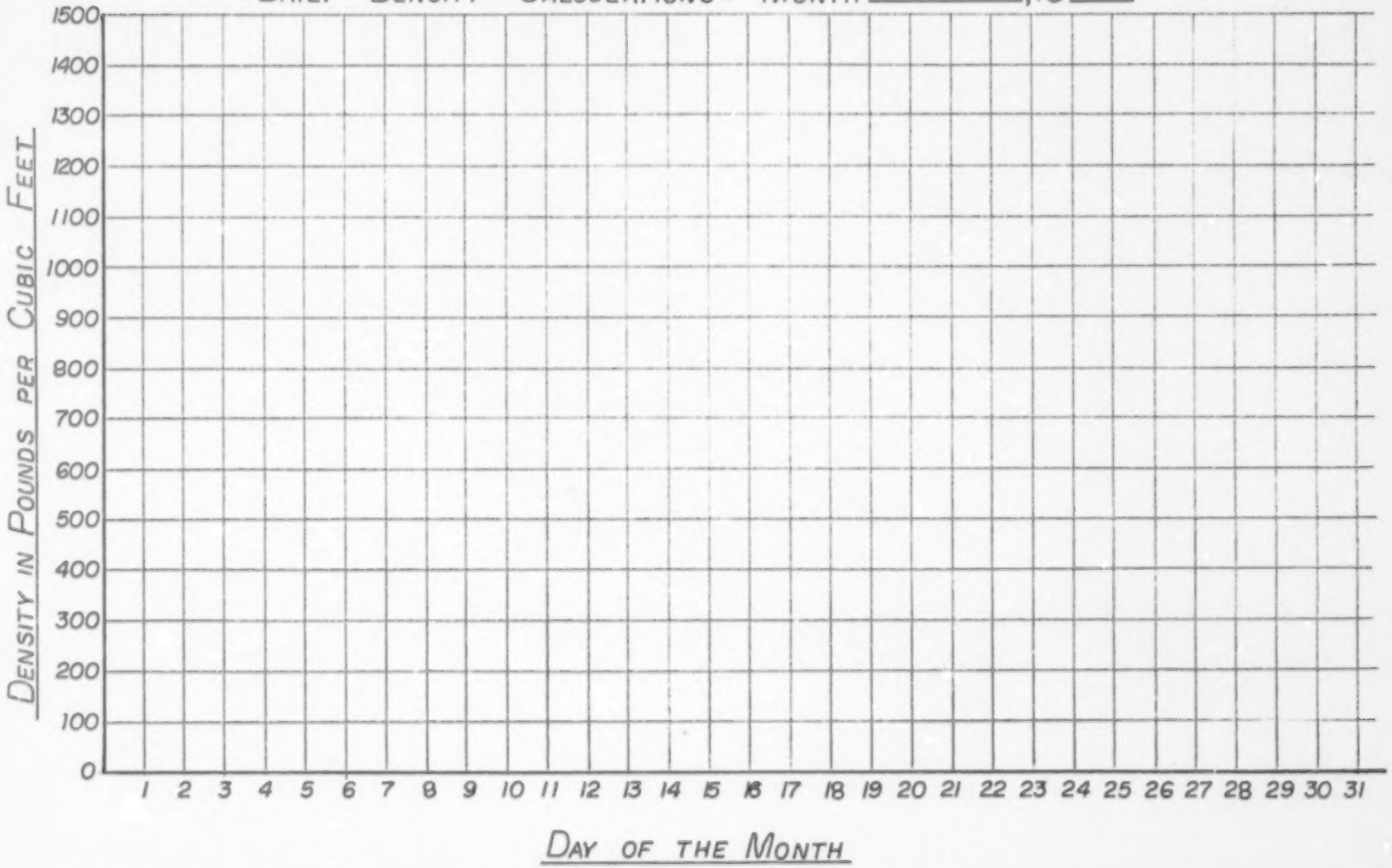
# APPENDIX A

## SAMPLE COPIES OF DAILY RECORD SHEETS AND CONVENTIONAL LANDFILL DATA

CRAWFORD COUNTY, OHIO

SANITARY LANDFILL DEMONSTRATION GRANT

DAILY DENSITY CALCULATIONS: MONTH _____, 19___



| DATE | MACHINE HOURS WORKED | FUEL | | GASOLINE | | LUBE OIL | | GREASE | | FILTERS | | HYDRAULIC OIL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AMOUNT USED | TOTAL COST | AMT. USED | TOTAL COST | AMT. USED | TOTAL USED | AMT. USED | TOTAL COST | NO. & TYPE | TOTAL COST | AMT. USED | TOTAL COST |
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| TOTALS | | | | | | | | | | | | | |

$$\text{Hourly Operating Cost} = \frac{\text{Total monthly cost}}{\text{Total machine hours worked}} = \text{cost per hour}$$

ITEM _____ MONTH _____

| | REPAIR PARTS | | REPAIR LABOR | | OPERATOR | | SERVICE METER | |
|---|---|---|---|---|---|---|---|---|
| | TYPE OF REPAIRS | TOTAL COST | TIME | TOTAL COST | TIME | TOTAL COST | READING | TYPE OF WORK DONE |
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* SERVICE METER TOTAL
Last reading

First reading

Difference

# DAILY WEIGHT RECORD

DATE: _____

| TRUCK | TIME | WASTES | | WEIGHT IN | WEIGHT OUT | SOLID WASTE PLACEMENT | |
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ROTO SHREDDER REJECTION

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|---|---|
| AMOUNT REJECTED | |
| FINAL WINDROW AMT. | |
| FINAL TRENCH AMT. | |

# LAND VOLUME

SITE _____ MONTH _____

| DATE | WEIGHT OF REFUSE | VOLUME OF REFUSE | VOLUME OF COVER Material | TOTAL VOLUME OF TRENCH USED | DENSITY OF REFUSE | NO. OF TIM COMPACTED |
|---|---|---|---|---|---|---|
| 1. | | | | | | |
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| 31. | | | | | | |
| TOTAL | | | | | | |

# ANALYSIS OF LEACHATE FROM TEST WELLS

| DATE | TEMP. | pH | $CH_4$ | $CO_2$ | D.O. | TOTAL SOLIDS | DRY WEIGHT | VOLA-TILE | CELLU-LOSE | $NO_3$ | $PO_4$ | MOIST-TURE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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ANALYSIS OF GAS FROM BURIED TUBES

| DATE | $CO_2$ | $O_2$ | $CH_4$ | | |
|---|---|---|---|---|---|
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TABLE III-1

CONVENTIONAL LANDFILL REFUSE WEIGHT DATA - 1970

| CATEGORY | MONTH | | | |
|---|---|---|---|---|
| | SEPT. | OCT. | NOV. | DEC. |
| 1. Density in Ton/Yd.$^3$ For Month | 0.337 | 0.351 | 0.474 | 0.392 |
| 2. Mean Daily Density in Ton/Yd.$^3$ | 0.387 | 0.385 | 0.491 | 0.391 |
| 3. *Mean Daily Tonnage in Ton/Day | | | | |
| TOTAL | 120.3 | 115.2 | 105.7 | 100.7 |
| Industrial | 45.6 | 28.3 | 22.4 | 27.1 |
| Commercial | 13.0 | 35.0 | 39.0 | 27.7 |
| Residential | 61.7 | 51.9 | 44.3 | 45.9 |
| 4. Mean Weekly Tonnage in Ton/Week | | | | |
| TOTAL | 619 | 598 | 520 | 474 |
| Industrial | 230 | 142 | 106.5 | 126.6 |
| Commercial | 72 | 186.5 | 198 | 130.7 |
| Residential | 317 | 270 | 225.4 | 217.6 |
| 5. Mean Tonnage For Week Days in Month in Ton/Day | | | | |
| MONDAY | 125 | 110 | 100 | 101 |
| TUESDAY | 133 | 112 | 108 | 100 |
| WEDNESDAY | 119 | 115 | 106 | 107 |
| THURSDAY | 116 | 125 | 113 | 97 |
| FRIDAY | 106 | 114 | 96 | 97 |
| SATURDAY | 17 | 22 | 25 | 17 |

* Values do not include Saturday data.

TABLE III-1 (Continued)

| CATEGORY | MONTH | | | |
|---|---|---|---|---|
| | SEPT. | OCT. | NOV. | DEC. |
| 6. Total Tonnage Filled During Month in Tons | | | | |
| Industrial | 691.0 | 568.5 | 426.0 | 628.0 |
| Commercial | 216.0 | 746.0 | 792.5 | 653.5 |
| Residential | 951.5 | 1079.0 | 901.5 | 1088.0 |
| TOTAL | 1858.5 | 2393.5 | 2120.0 | 2369.5 |
| 7. Average Loads per Week During Month Loads/Week | | | | |
| Industrial | 71 | 34 | 29 | 46 |
| Commercial | 50 | 106 | 110 | 80 |
| Residential | 110 | 95 | 82 | 95 |
| TOTAL | 241 | 235 | 221 | 221 |

TABLE III-2

CONVENTIONAL LANDFILL CAPITAL COSTS

| | ANNUAL |
|---|---|
| MAINTENANCE BUILDING | |
| $30,067.00 @ 6% - 20 years | $ 2,621.24 |
| LAND | |
| $86,625.00 @ 6% - 20 years | 7,551.97 |
| ROAD AND SITE IMPROVEMENTS | |
| $51,358.25 @ 6% - 10 years | 6,978.05 |
| ENGINEERING | |
| $11,772.45 @ 6% - 20 years | 1,026.32 |
| CRAWLER-DOZER | |
| $41,408.00 @ 6% - 5 years | 9,830.25 |
| DRAGLINE | |
| $50,585.00 @ 6% - 12 years | 6,033.78 |
| DUMP TRUCK | |
| $2,300.00 @ 6% - 5 years | 546.02 |
| GRADER | |
| $2,500.00 @ 6% - 5 years | 593.50 |
| TOTAL ANNUAL CAPITAL COST | $35,181.13 |

TABLE III-3

EXPENSE ESTIMATE

| | ANNUAL | 4-WEEKS |
|---|---|---|
| AMORTIZATION EXPENSE | | |
| Land | $ 7,551.97 | $ 580.93 |
| Buildings | 2,621.24 | 201.64 |
| Road and Site Improvements | 6,978.05 | 536.77 |
| Engineering | 1,026.32 | 78.95 |
| Crawler | 9,830.25 | 756.17 |
| Dragline | 6,033.78 | 464.14 |
| Dump Truck | 546.02 | 42.00 |
| Grader | 593.50 | 45.66 |
| TOTALS | $35,181.13 | $2,706.26 |
| OPERATIONAL COSTS | | |
| Labor | $27,207.36 | $2,092.84 |
| Gasoline and Lubricants | 3,500.00 | 269.23 |
| Parts and Tools | 2,200.00 | 169.23 |
| Utilities, Supplies, etc. | 3,700.00 | 284.62 |
| Equipment Rental | 750.00 | 57.70 |
| Landfill Maintenance | 1,600.00 | 123.08 |
| TOTALS | $38,957.36 | $2,996.70 |

TABLE III-4

CONVENTIONAL LANDFILL EVALUATION SHEET

PERIOD: SEPTEMBER 14-OCTOBER 3, 1970

| | | |
|---|---|---|
| REFUSE DATA | | |
| Total Amount Filled | 1858.5 Tons | |
| Density for Period | 0.337 Tons/Yd.$^3$ | |
| Mean Daily Density | 0.387 Tons/Yd.$^3$ | |
| Total Industrial Refuse | 691.0 Tons | |
| Total Commercial Refuse | 216.0 Tons | |
| Total Residential Refuse | 951.5 Tons | |
| LABOR | STRAIGHT TIME | OVER TIME |
| Landfill Supervisor | 120 Hrs. | 28 Hrs. |
| Equipment Operator | 120 Hrs. | 21 Hrs. |
| Clerk-Secretary | 120 Hrs. | 15 Hrs. |
| MACHINE USAGE | | |
| Crawler Dozer | 111 Hrs. | |
| Dragline | 60 Hrs. | |
| Grader | 7 Hrs. | |
| EXPENSES | | |
| Amortization | $2,029.70 | |
| Operation Cost | 2,266.59 | |
| TOTAL | $4,296.29 | |
| COST | $2.31 per Ton | |

TABLE III-5

CONVENTIONAL LANDFILL EVALUATION SHEET

PERIOD: OCTOBER 5-OCTOBER 31, 1970

| | | |
|---|---|---|
| REFUSE DATA | | |
| Total Amount Filled | 2393.5 Tons | |
| Density for Period | 0.351 Tons/Yd.$^3$ | |
| Mean Daily Density | 0.385 Tons/Yd.$^3$ | |
| Total Industrial Refuse | 568.5 Tons | |
| Total Commercial Refuse | 746.0 Tons | |
| Total Residential Refuse | 1079.0 Tons | |
| LABOR | STRAIGHT TIME | OVER TIME |
| Landfill Supervisor | 160 Hrs. | 47 Hrs. |
| Equipment Operator | 160 Hrs. | 45 Hrs. |
| Clerk-Secretary | 160 Hrs. | 20 Hrs. |
| MACHINE USAGE | | |
| Crawler Dozer | 142 Hrs. | |
| Dragline | 103 Hrs. | |
| Grader | 5 Hrs. | |
| EXPENSES | | |
| Amortization | $2,706.26 | |
| Operational Cost | 2,996.70 | |
| TOTAL | $5,702.96 | |
| COST | $2.38 per Ton | |

TABLE III-6

CONVENTIONAL LANDFILL EVALUATION SHEET

PERIOD: NOVEMBER 2-NOVEMBER 28, 1970

| | | |
|---|---|---|
| REFUSE DATA | | |
| Total Amount Filled | 2120.0 Tons | |
| Density for Period | 0.474 Tons/Yd.$^3$ | |
| Mean Daily Density | 0.491 Tons/Yd.$^3$ | |
| Total Industrial Refuse | 426.0 Tons | |
| Total Commercial Refuse | 792.5 Tons | |
| Total Residential Refuse | 901.5 Tons | |
| LABOR | STRAIGHT TIME | OVER TIME |
| Landfill Supervisor | 112 Hrs. | 41 Hrs. |
| Equipment Operator | 112 Hrs. | 41 Hrs. |
| Clerk-Secretary | 112 Hrs. | 20 Hrs. |
| MACHINE USAGE | | |
| Crawler Dozer | 144 Hrs. | |
| Dragline | 123 Hrs. | |
| Grader | 6 Hrs. | |
| EXPENSES | | |
| Amortization | $2,706.26 | |
| Operational Cost | 2,896.70 | |
| TOTAL | $5,702.96 | |
| COST | $2.69 per Ton | |

TABLE III-7

CONVENTIONAL LANDFILL EVALUATION SHEET

PERIOD: NOVEMBER 30-DECEMBER 31, 1970

| | | |
|---|---|---|
| REFUSE DATA | | |
| Total Amount Filled | 2369.5 Tons | |
| Density for Period | 0.392 Tons/Yd.$^3$ | |
| Mean Daily Density | 0.391 Tons/Yd.$^3$ | |
| Total Industrial Refuse | 628.0 Tons | |
| Total Commercial Refuse | 653.5 Tons | |
| Total Residential Refuse | 1088.0 Tons | |
| LABOR | STRAIGHT TIME | OVER TIME |
| Landfill Supervisor | 192 Hrs. | 31 Hrs. |
| Equipment Operator | 192 Hrs. | 31 Hrs. |
| Clerk-Secretary | 184 Hrs. | 15 Hrs. |
| MACHINE USAGE | | |
| Crawler Dozer | 177 Hrs. | |
| Dragline | 78 Hrs. | |
| Grader | 8 Hrs. | |
| EXPENSES | | |
| Amortization | $3,382.83 | |
| Operational Cost | 3,777.65 | |
| TOTAL | $7,160.48 | |
| COST | $3.02 per Ton | |

TABLE IV-1

SHREDDING DATA

SIEVE ANALYSIS

| DATE | DRUM SPEED | NO. OF PASSES | PERCENT RETAINED IN SIEVE SIZE 7" | 3-1/2" | 1-1/2" | 3/4" | BIN |
|---|---|---|---|---|---|---|---|
| 1-6-71 | 225 | 2 | 13.3 | 20.0 | 26.7 | 13.3 | 26.7 |
| 1-21-71 | 225 | 2 | 6.0 | 41.2 | 21.9 | 14.6 | 16.3 |
| 1-28-71 | 225 | 2 | 40.1 | 22.2 | 18.4 | 6.8 | 12.5 |
| 1-29-71 | 225 | 2 | 1.4 | 33.6 | 41.9 | 2.8 | 20.3 |
| 2-3-71 | 225 | 6 | 6.3 | 37.5 | 38.5 | 4.2 | 13.5 |
| 2-3-71 | 225 | 6 | 4.4 | 35.3 | 33.8 | 11.8 | 14.7 |
| 2-8-71 | 225 | 6 | 16.4 | 35.2 | 27.1 | 15.6 | 5.7 |
| 2-9-71 | 225 | 6 | 16.7 | 23.5 | 29.4 | 15.7 | 14.7 |
| 2-11-71 | 225 | 6 | 1.3 | 32.1 | 34.6 | 12.8 | 19.2 |
| 3-16-71 | Max. | 2 | 4.7 | 34.9 | 28.8 | 13.8 | 21.2 |
| 3-18-71 | Max. | 2 | 4.6 | 35.4 | 38.5 | 12.3 | 9.2 |
| 3-18-71 | Max. | 2 | 6.2 | 33.3 | 33.3 | 8.7 | 18.5 |
| 3-22-71 | Max. | 2 | 10.5 | 27.8 | 36.1 | 9.3 | 16.3 |
| 3-24-71 | Max. | 2 | 20.3 | 29.7 | 20.3 | 10.1 | 19.6 |

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TABLE IV-2

SHREDDING DATA

COMPOSITION ANALYSIS

| DATE | TOTAL SHREDDED TONS | TOTAL DENSITY TONS/YD.$^3$ | PAPER AND RAGS | CLASSIFICATIONS - % TOTAL YARD TRIMMINGS | INERTS | GARBAGE AND FINES |
|---|---|---|---|---|---|---|
| 1-6-71 | 36.5 | .444 | 42.8 | 0 | 14.4 | 42.8 |
| 1-21-71 | 17.5 | .513 | 32.5 | 4.3 | 32.0 | 31.2 |
| 1-28-71 | 12.4 | --- | 44.9 | 0 | 29.0 | 26.1 |
| 1-29-71 | 10.6 | --- | 48.3 | 0 | 24.4 | 27.3 |
| 2-3-71 | 11.6 | 0.465 | 66.6 | 0 | 16.7 | 16.7 |
| 2-3-71 | 11.6 | 0.465 | 63.2 | 0 | 11.8 | 25.0 |
| 2-8-71 | 19.8 | 0.350 | 58.9 | 17.7 | 16.9 | 6.5 |
| 2-9-71 | 7.2 | 0.350 | 34.5 | 0 | 22.8 | 42.7 |
| 2-11-71 | 7.0 | 0.458 | 62.8 | 0 | 16.7 | 20.5 |
| 2-16-71 | 17.9 | --- | 53.8 | 0 | 20.8 | 25.4 |
| 3-18-71 | 18.2 | .382 | 64.6 | 0 | 26.2 | 9.2 |
| 3-18-71 | 18.2 | .382 | 58.6 | 4.3 | 17.9 | 19.2 |
| 3-22-71 | 20.9 | .519 | 47.6 | 0 | 22.1 | 30.3 |

TABLE IV-3

COMPOSITION ANALYSIS

| DATE | TOTAL SHREDDED TONS | TOTAL DENSITY TONS/YD$^3$ | CLASSIFICATIONS - % PAPER | RAGS | GLASS | METAL | PLASTIC | WOOD & YARD TRIMMINGS | GARBAGE | FINES |
|---|---|---|---|---|---|---|---|---|---|---|
| 6-21-71 | 23.53 | .360* | 48.20 | 3.10 | 10.80 | 7.60 | 14.20 | 4.60 | 6.80 | 4.70 |
| 6-22-71 | 44.72 | .389* | 52.61 | Trace | 7.22 | 5.63 | 3.21 | 9.63 | 20.10 | 1.60 |
| 6-23-71 | 39.18 | .410 | 56.25 | 3.10 | 8.62 | 10.10 | 9.60 | 6.33 | 4.25 | 1.75 |
| 6-24-71 | 23.58 | .416 | 45.20 | 3.90 | 10.20 | 8.10 | 12.50 | 13.60 | 4.70 | 1.80 |
| 6-25-71 | 31.02 | .412 | 51.20 | 4.10 | 8.50 | 7.30 | 13.70 | 9.20 | 3.90 | 2.10 |
| 6-28-71 | 29.09 | .327** | 61.25 | 2.75 | 6.33 | 7.50 | 7.19 | 8.48 | 5.11 | 1.39 |
| 6-29-71 | 39.19 | .370** | 57.66 | 2.16 | 5.44 | 8.80 | 6.74 | 15.73 | 2.20 | 1.27 |
| 6-30-71 | 25.68 | .361** | 41.37 | 3.70 | 7.32 | 11.77 | 8.32 | 17.86 | 7.62 | 2.04 |

* Start of New Trench and Compaction More Difficult until Proper End Slope Is Built

** Regular Operator on Vacation

TABLE IV-4

SHREDDING DATA

| DATE | TOTAL TONS RECEIVED | TONS SHREDDED | ROTO-SHREDDER HRS. | ROTO-SHREDDER PASSES | CRAWLER PUSHING IN | HRS. COMPACTION | CLEAN UP EQUIP. HRS. | CLEAN UP MAN HRS. | DAILY DENSITY |
|---|---|---|---|---|---|---|---|---|---|
| 6-21-71 | 90 | 23.53 | 1.50 | 2 | 0.33 HR. | 0.62 HR. | 0.75 | 1.50 | 0.360 TON/YD. |
| 6-22-71 | 97.23 | 44.72 | 1.83 | 2 | 0.66 HR. | 1.09 HR. | 0.83 | 1.66 | 0.389 TON/YD. |
| 6-23-71 | 105.52 | 39.18 | 0.83 | 2 | 0.55 HR. | 1.25 HR. | 0.66 | 2.0 | 0.410 TON/YD. |
| 6-24-71 | 91.2 | 23.58 | 0.55 | 2 | 0.75 HR. | 0.91 HR. | 0.41 | 0.66 | 0.416 TON/YD. |
| 6-25-71 | 92.3 | 31.02 | 0.75 | 2 | 0.50 HR. | 0.83 HR. | 0.41 | 0.58 | 0.412 TON/YD. |
| 6-28-71 | 86.24 | 29.09 | 1.11 | 6 | 0.42 HR. | 0.66 HR. | 0.25 | 0.70 | 0.327 TON/YD. |
| 6-29-71 | 126 | 39.19 | 1.33 | 6 | 0.50 HR. | 0.83 HR. | 0.41 | 1.66 | 0.370 TON/YD. |
| 6-30-71 | 96.53 | 25.68 | 1.0 | 6 | 0.66 HR. | 1.00 HR. | 0.66 | 1.66 | 0.361 TON/YD. |

NOTE: THE SHREDDED REFUSE WAS LANDFILLED IN A SEPARATE TRENCH

APPENDIX C

LETTERS OF APPROVAL

**ENVIRONMENTAL PROTECTION AGENCY**

Solid Wastes Office

Date: FEB 3 1971

Reply to
Attn of:

Subject: Results of Meeting Concerning Project 1-G06-EC-00297-01, Crawford County, Ohio Sanitary Landfill

To: The Record

1. On February 2, 1971, Mr. Bob Jones, Project Director, and I met with Messrs. Lynn Wallace, Dan Bender, Norbert Schomaker, Dirk Brunner, and Jim Geyer to discuss a preproposal concerning the measurement of the digestion rates of raw, shredded, and composted refuse.

2. The following suggestions and comments were offered:

a. Concerning the two test cells containing composted refuse, one cell will contain refuse composted for three weeks, and the other, refuse composted for six weeks.

b. All refuse used in the tests will be taken from the Tuesday and Thursday refuse collections. Earlier work has shown that these collections contain similar refuse.

c. A separation study should be run on the refuse. The Division of Technical Operations can provide technical assistance.

d. A six inch layer of clay should surround the refuse and be contained within the cell. This will help prevent puncturing of the liner material and avoid the argument that soil bacteria are needed to help seed the refuse.

e. The same compactive effort and same weight of refuse should be used for each test cell.

f. An attempt should be made to correlate the amount of water added to the test cells with the actual rainfall of a selected region. The amount of rainwater that would percolate through the cover material should be taken into account. The yearly percolating rainfall should be added to the cells in equal weekly increments.

g. The two proposed leachate lines should be installed in case one line clogs.

h. The quantity of leachate should be recorded. All of the leachate in the sump should be drained each time a sample is taken

so that future samples will not be contaminated with past leachate.

i. A gas line should also be installed near the top of the cell in addition to the gas line at the cell bottom.

j. Precompacting before taking settling measurements is not advised since this would add to the total compactive effort applied to the cells. This may reduce void space or otherwise affect the digestion rate in the test cells.

k. The stress from the block that is used as a base for the settlement measurements should not exceed 500 - 800 $lb/ft^2$. The block should be placed directly on the vinyl at the top of the cell.

l. The Pennsylvania State Health Department is conducting research work on the BOD test as applied to leachate analysis.

m. After production measurements, the gas coming from the cells should be vented well above the ground level. A burner could be used if odor problems develop.

n. Concerning the individual bags of refuse (simulated grab samples), 200 - 300 lbs. of raw refuse should be used to assure a good sample. Water should be added to the bags in an amount proportional to that added to the cells on a weight basis. Holes should be punched in the bags to allow the leachate and gas to escape. The percent moisture should be calculated on a dry weight basis. The entire bag of refuse should be ground prior to sampling for the volatile solids, cellulose, and C/N tests.

o. Alkalinity tests should also be run on leachate.

p. Unknown peaks from the gas chromatograph may be due to $H_2S$ and CO.

q. Concerning the budget:

(1) Blower not needed.

(2) Only one leachate pump is needed.

(3) The various sample analysis should be budgeted on a unit cost basis with the project consultants.

3. It was felt by those attending the meeting that the results obtained from the proposal, with due cognizance of the suggestions and comments mentioned above, would adequately satisfy an objective of the project, and would also add to the basic research data that is badly needed by the Solid Wastes Office.

Bob Holloway

J. Robert Holloway, Project Officer
Processing and Recovery Branch
Division of Demonstration Operations

cc. Dr. Lynn Wallace
Dr. Dan Bender
Region V
B. Holloway
Official File - Original
Mr. Talty's Reading File

SWO:JRHolloway:mjg:2/17/71

JOHN J. GILLIGAN, Governor

450 East Town Street
P.O. Box 118
Columbus, Ohio 43216

# State of Ohio

# Department of Health

NORTHWEST DISTRICT OFFICE
Bowling Green, Ohio 43402

Re: Crawford County
Sanitary Landfill
(Grant Project)
Solid Waste

March 4, 1971

Mr. Robert C. Jones, P. E.
P. O. Box 27
Napoleon, Ohio 43545

Dear Mr. Jones:

On February 22, 1971, detail plans of a supplemental proposal for operation at the Crawford County Landfill were received at this office for review. The project is in conjunction with the Federal Grant being pursued.

Basically the proposal is to explore gas production of three (3) types of solid waste material:

1) Ordinary unshredded residential refuse

2) Pre-shredded refuse

3) Pre-shredded and pre-composted refuse

Operation will be during April, and is specified as to which two days of each week it will be done. Plans and the description of operation appear satisfactory as proposed.

Plans have been distributed to persons involved as shown below in the copy list.

Yours truly,

Dan T. Redman

Dan T. Redman, P. E.
District Sanitary Engineer

DTR/gps
Enclosure

cc: w/plans - Don Day
cc: w/plans - Crawford Co. Commrs.
cc: w/plans - Crawford Co. Health Dept.
cc: letter only - John Baughman
cc: " " - Ken Kerik
cc: " " - Ivan Baker

# APPENDIX D

## TEST CELL DATA AND CELL CONSTRUCTION DRAWINGS

TABLE VI-1

CELL NO.1 REFUSE CATEGORIES

| SAMPLE | | PAPER | RAGS | GLASS | METAL | PLASTIC | WOOD & YARD TRIMMINGS | GARBAGE | FINES | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | lbs. | 193.75 | 10.50 | 34.50 | 23.38 | 15.75 | 29.75 | 15.37 | 4.65 | 327.65 |
| | % | 59.1% | 3.2% | 10.5% | 7.1% | 4.8% | 9.0% | 4.6% | 1.4% | |
| 2 | lbs. | 133.87 | 18.50 | 19.88 | 24.62 | 13.75 | 75.38 | 20.25 | 4.33 | 310.58 |
| | % | 43.1% | 6.0% | 6.4% | 7.9% | 4.4% | 24.3% | 6.5% | 1.4% | |
| 3 | lbs. | 223.63 | 15.25 | 8.12 | 29.50 | 11.38 | 56.62 | 12.25 | 5.13 | 360.78 |
| | % | 61.9% | 4.2% | 2.2% | 8.2% | 3.1% | 15.7% | 3.4% | 1.4% | |
| 4 | lbs. | 175.00 | 3.44 | 43.88 | 23.93 | 12.11 | 57.27 | 3.12 | 7.82 | 321.57 |
| | % | 53.6% | 1.1% | 13.4% | 7.3% | 3.7% | 17.5% | 1.0% | 2.4% | |
| AVERAGE % | | 54.4% | 3.6% | 8.1% | 7.6% | 4.0% | 16.6% | 3.9% | 1.6% | |

TABLE VI-2

CELL NO.2 REFUSE CATEGORIES

| SAMPLE | PAPER | RAGS | GLASS | METAL | PLASTIC | WOOD & YARD TRIMMINGS | GARBAGE | FINES | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 1 lbs. | 169.00 | 7.54 | 36.38 | 28.33 | 14.71 | 46.47 | 6.24 | 3.56 | 312.23 |
| % | 54.1% | 2.41% | 11.65% | 9.07% | 4.7% | 14.8% | 2.0% | 1.14% | |
| 2 lbs. | 220.13 | 7.00 | 8.50 | 29.12 | 12.38 | 64.50 | 9.12 | 10.33 | 361.08 |
| % | 60.97% | 1.93% | 2.35% | 8.06% | 3.43% | 17.86% | 2.52% | 2.86% | |
| 3 lbs. | 190.18 | 3.50 | 6.50 | 19.75 | 18.87 | 63.13 | 31.38 | 6.50 | 339.80 |
| % | 55.96% | 1.03% | 1.91% | 5.81% | 5.55% | 18.57% | 9.23% | 1.91% | |
| 4 lbs. | 154.25 | 7.75 | 38.00 | 46.88 | 17.25 | 19.88 | 24.38 | 20.63 | 330.62 |
| % | 46.88% | 2.35% | 11.55% | 14.24% | 5.22% | 6.02% | 7.38% | 6.25% | |
| AVERAGE % | 54.46% | 1.93% | 6.86% | 9.29% | 4.72% | 14.31% | 5.28% | 3.04% | |

TABLE VI-3

CELL NO.3 REFUSE CATEGORIES

| SAMPLE | PAPER | RAGS | GLASS | METAL | PLASTIC | WOOD & YARD TRIMMINGS | GARBAGE | FINES | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 1 lbs. | 195.12 | 10.87 | 25.50 | 45.07 | 16.00 | 51.59 | 14.85 | 12.50 | 371.50 |
| % | 52.52% | 2.92% | 6.86% | 12.13% | 4.40% | 13.88% | 3.99% | 3.36% | |
| 2 lbs. | 193.50 | 11.25 | 13.87 | 13.42 | 12.82 | 66.71 | 6.95 | 5.63 | 348.15 |
| % | 55.57% | 3.23% | 3.98% | 10.74% | 3.68% | 19.16% | 2.0 % | 1.6 % | |
| 3 lbs. | 154.75 | 18.88 | 44.75 | 23.25 | 41.75 | 26.87 | 29.00 | 12.25 | 351.50 |
| % | 44.02% | 5.37% | 12.73% | 6.61% | 11.87% | 7.64% | 8.25% | 3.48% | |
| 4 lbs. | 121.25 | 7.25 | 31.75 | 29.75 | 62.12 | 9.50 | 18.25 | 14.13 | 294.00 |
| % | 41.24% | 2.46% | 10.79% | 10.11% | 21.12% | 3.23% | 6.20% | 4.80% | |
| AVERAGE % | 48.33% | 3.49% | 8.59% | 9.89% | 10.24% | 10.18% | 5.11% | 3.31% | |

TABLE VI-4

CELL NO.4 REFUSE CATEGORIES

| SAMPLE | PAPER | RAGS | GLASS | METAL | PLASTIC | WOOD & YARD TRIMMINGS | GARBAGE | FINES | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 1 lbs. | 125.00 | 10.63 | 34.37 | 22.37 | 51.37 | 14.75 | 20.88 | 12.63 | 292.00 |
| % | 42.51% | 3.64% | 11.77% | 7.66% | 17.59% | 5.05% | 7.15% | 4.32% | |
| 2 lbs. | 137.50 | 11.00 | 37.37 | 26.25 | 59.12 | 15.12 | 22.25 | 14.25 | 322.86 |
| % | 42.58% | 3.40% | 11.57% | 8.13% | 18.13% | 4.68% | 6.89% | 4.41% | |
| 3 lbs. | 133.88 | 11.50 | 37.12 | 24.37 | 55.75 | 15.75 | 22.50 | 13.75 | 314.62 |
| % | 42.55% | 3.33% | 11.79% | 7.74% | 17.71% | 5.00% | 7.15% | 4.37% | |
| 4 lbs. | 164.37 | 11.12 | 38.00 | 21.50 | 51.25 | 26.88 | 36.50 | 15.62 | 365.24 |
| % | 45.00% | 3.04% | 10.40% | 5.88% | 14.03% | 7.35% | 10.00% | 4.27% | |
| AVERAGE % | 43.16% | 3.35% | 11.38% | 7.35% | 16.91% | 5.52% | 7.79% | 4.34% | |

TABLE VI-5

CELL NO.4 REFUSE CATEGORIES

| SAMPLE | PAPER | RAGS | GLASS | METAL | PLASTIC | WOOD & YARD TRIMMINGS | GARBAGE | FINES | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 1 lbs. | 149.00 | 13.63 | 26.88 | 19.00 | 53.37 | 21.50 | 28.63 | 22.62 | 334.63 |
| % | 44.52% | 4.07% | 8.03% | 5.67% | 15.94% | 6.42% | 8.55% | 6.75% | |
| 2 lbs. | 146.50 | 6.37 | 41.50 | 20.37 | 39.00 | 27.12 | 37.38 | 5.50 | 323.74 |
| % | 45.25% | 1.96% | 12.81% | 6.29% | 12.04% | 8.37% | 11.54% | 1.69% | |
| 3 lbs. | 134.50 | 5.75 | 8.38 | 16.62 | 80.13 | 20.88 | 29.25 | 23.62 | 319.13 |
| % | 42.14% | 1.80% | 2.62% | 5.20% | 25.10% | 6.54% | 9.16% | 7.40% | |
| 4 lbs. | 203.75 | 5.63 | 22.13 | 27.63 | 49.75 | 16.50 | 5.63 | 44.12 | 375.14 |
| % | 54.31% | 1.50% | 5.89% | 7.36% | 13.26% | 4.39% | 1.50% | 11.76% | |
| AVERAGE % | 46.55% | 2.33% | 7.34% | 6.13% | 16.58% | 6.63% | 7.68% | 6.90% | |

TABLE VI-6

CELL NO.6 REFUSE CATEGORIES

| SAMPLE | PAPER | RAGS | GLASS | METAL | PLASTIC | WOOD & YARD TRIMMINGS | GARBAGE | FINES | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 1 lbs. | 105.50 | 7.75 | 11.50 | 27.00 | 77.50 | 10.25 | 16.38 | 17.37 | 273.25 |
| % | 38.60% | 2.83% | 4.20% | 9.88% | 28.36% | 3.75% | 5.99% | 6.35% | |
| 2 lbs. | 154.00 | 9.50 | 7.50 | 22.63 | 26.37 | 31.25 | 26.50 | 14.37 | 292.12 |
| % | 52.71% | 3.25% | 2.56% | 7.74% | 9.02% | 10.69% | 9.07% | 4.91% | |
| 3 lbs. | 157.75 | 6.88 | 39.00 | 24.38 | 25.88 | 39.75 | 8.75 | 5.00 | 307.39 |
| % | 51.31% | 2.23% | 12.68% | 7.93% | 8.41% | 12.93% | 2.84% | 1.62% | |
| 4 lbs. | 218.75 | 3.75 | 11.88 | 19.62 | 20.75 | 19.62 | 17.00 | 5.25 | 316.62 |
| % | 69.08% | 1.18% | 3.75% | 6.19% | 6.55% | 6.19% | 5.36% | 1.65% | |
| AVERAGE % | 52.92% | 2.37% | 5.79% | 7.83% | 13.08% | 8.39% | 5.81% | 3.63% | |

TABLE VI-7

WET TYPE GAS METER READING

| DATE | CELL #1 Rd'g In CU. FT. | CELL #1 Diff. In CU. FT. | CELL #2 Rd'g In CU. FT. | CELL #2 Diff. In CU. FT. | CELL #3 Rd'g In CU. FT. | CELL #3 Diff. In CU. FT. | CELL #4 Rd'g In CU. FT. | CELL #4 Diff. In CU. FT. | CELL #5 Rd'g In CU. FT. | CELL #5 Diff. In CU. FT. | CELL #6 Rd'g In CU. FT. | CELL #6 Diff. In CU. FT. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5-13-71 | 94 | --- | 16 | --- | 15 | --- | | | | | | |
| 5-17-71 | 267 | 173 | 95 | 79 | 77 | 62 | 4 | --- | | | | |
| 5-18-71 | 279 | 12 | 95 | 0 | 60 | -17 | 4 | 0 | | | | |
| 5-19-71 | 288 | 9 | 95 | 0 | 41 | -19 | 4 | 0 | | | | |
| 5-20-71 | 328 | 40 | 95 | 0 | 41 | 0 | 4 | 0 | | | | |
| 5-21-71 | 315 | -13 | 81 | -6 | 41 | 0 | 4 | 0 | 0 | | 0 | |
| 5-24-71 | 315 | 0 | 81 | 0 | 41 | 0 | 4 | 0 | 0 | | 0 | |
| 5-25-71 | 316 | 1 | 81 | 0 | 41 | 0 | 4 | 0 | 0 | | 0 | |
| 5-26-71 | 316 | 0 | 81 | 0 | 41 | 0 | 4 | 0 | 0 | | 0 | |
| 5-27-71 | 316 | 0 | 78 | -3 | 41 | 0 | 4 | 0 | 0 | | 0 | |
| 5-28-71 | 316 | 0 | 78 | 0 | 41 | 0 | 4 | 0 | 0 | | 0 | |

TABLE VI-8

WET TYPE GAS METER READING

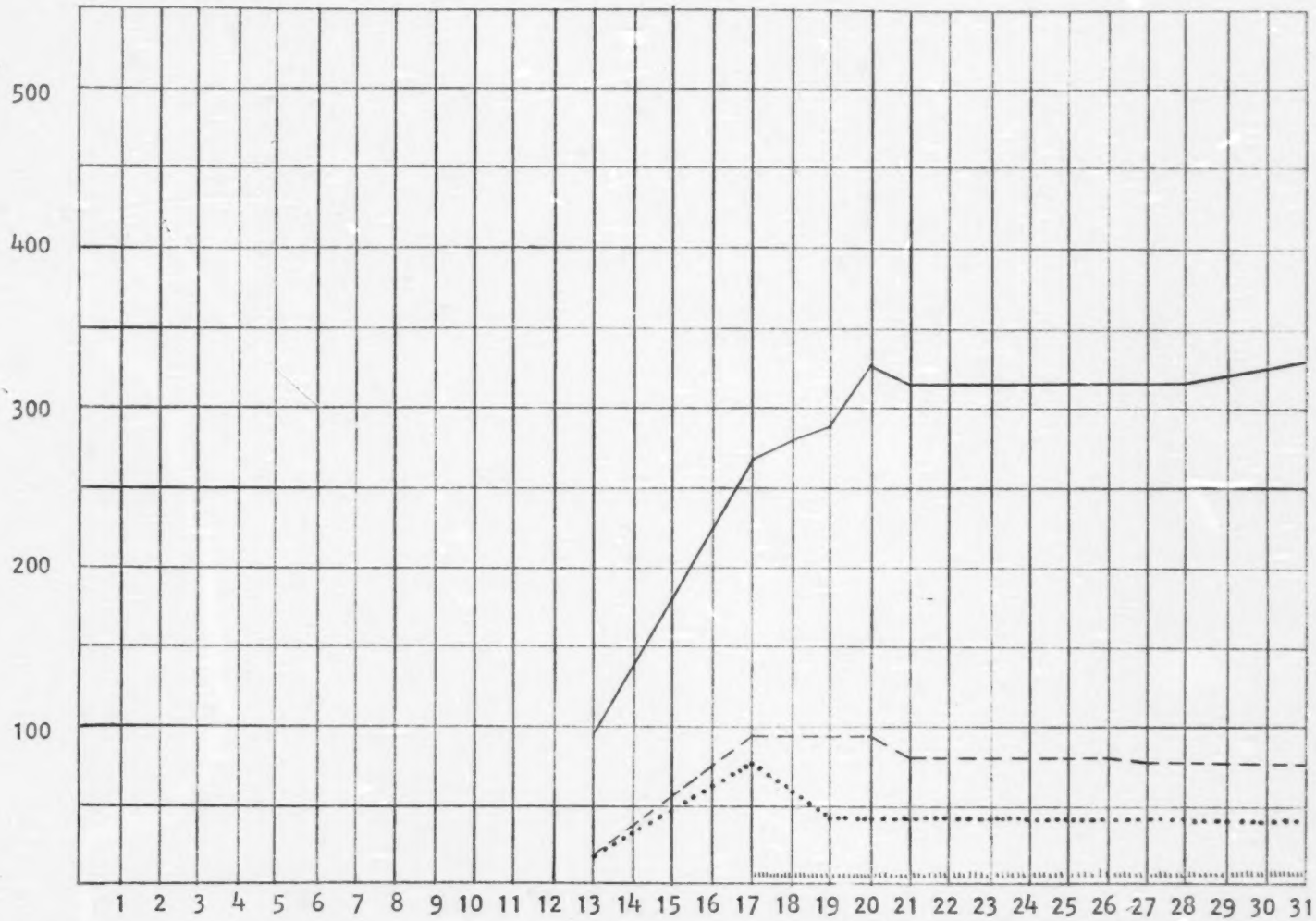
| DATE | CELL #1 Rd'g In CU. FT. | CELL #1 Diff. In CU. FT. | CELL #2 Rd'g In CU. FT. | CELL #2 Diff. In CU. FT. | CELL #3 Rd'g In CU. FT. | CELL #3 Diff. In CU. FT. | CELL #4 Rd'g In CU. CT. | CELL #4 Diff.In CU. FT. | CELL #5 Rd'g In CU. FT. | CELL #5 Diff. In CU. FT. | CELL #6 Rd'g In CU. FY. | CELL #6 Diff. In CU. FT. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6-1-71 | 333 | 17 | 75 | -3 | 41 | 0 | 4 | 0 | | | | |
| 6-2-71 | 333 | 0 | 75 | 0 | 41 | 0 | 4 | 0 | | | | |
| 6-3-71 | 333 | 0 | 75 | 0 | 41 | 0 | 4 | 0 | | | | |
| 6-4-71 | 333 | 0 | 75 | 0 | 41 | 0 | 4 | 0 | | | | |
| 6-7-71 | 452 | 119 | 75 | 0 | 41 | 0 | 4 | 0 | | | | |
| 6-8-71 | 478 | 26 | 64 | -11 | 49 | 8 | 4 | 0 | | | | |
| 6-9-71 | 478 | 0 | 64 | 0 | 48 | -1 | 4 | 0 | | | | |
| 6-10-71 | 478 | 0 | 64 | 0 | 48 | 0 | 4 | 0 | | | | |
| 6-11-71 | 478 | 0 | 64 | 0 | 48 | 0 | 4 | 0 | | | | |
| 6-14-71 | 544 | 66 | 42 | -22 | 47 | -1 | 4 | 0 | | | | |
| 6-15-71 | 544 | 0 | 38 | - 4 | 47 | 0 | 4 | 0 | | | | |

TABLE VI-8 CONTINUED

WET TYPE GAS METER READING

| DATE | CELL #1 Rd'g In CU. FT. | CELL #1 Diff. In CU. FT. | CELL #2 Rd'g In CU. FT. | CELL #2 Diff. In CU. FT. | CELL #3 Rd'g In CU. FT. | CELL #3 Diff. In CU. FT. | CELL #4 Rd'g In CU. FT. | CELL #4 Diff. In CU. FT. | CELL #5 Rd'g In CU. FT. | CELL #5 Diff. In CU. FT. | CELL #6 Rd'g In CU. FT. | CELL #6 Diff. In CU. FT. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6-16-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |
| 6-17-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |
| 6-18-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |
| 6-21-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |
| 6-22-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |
| 6-23-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |
| 6-24-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |
| 6-25-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |
| 6-28-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |
| 6-29-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |
| 6-30-71 | 544 | 0 | 38 | 0 | 47 | 0 | 4 | 0 | | | | |

CHART 1




MAY, 1971

GAS IN TEST CELLS

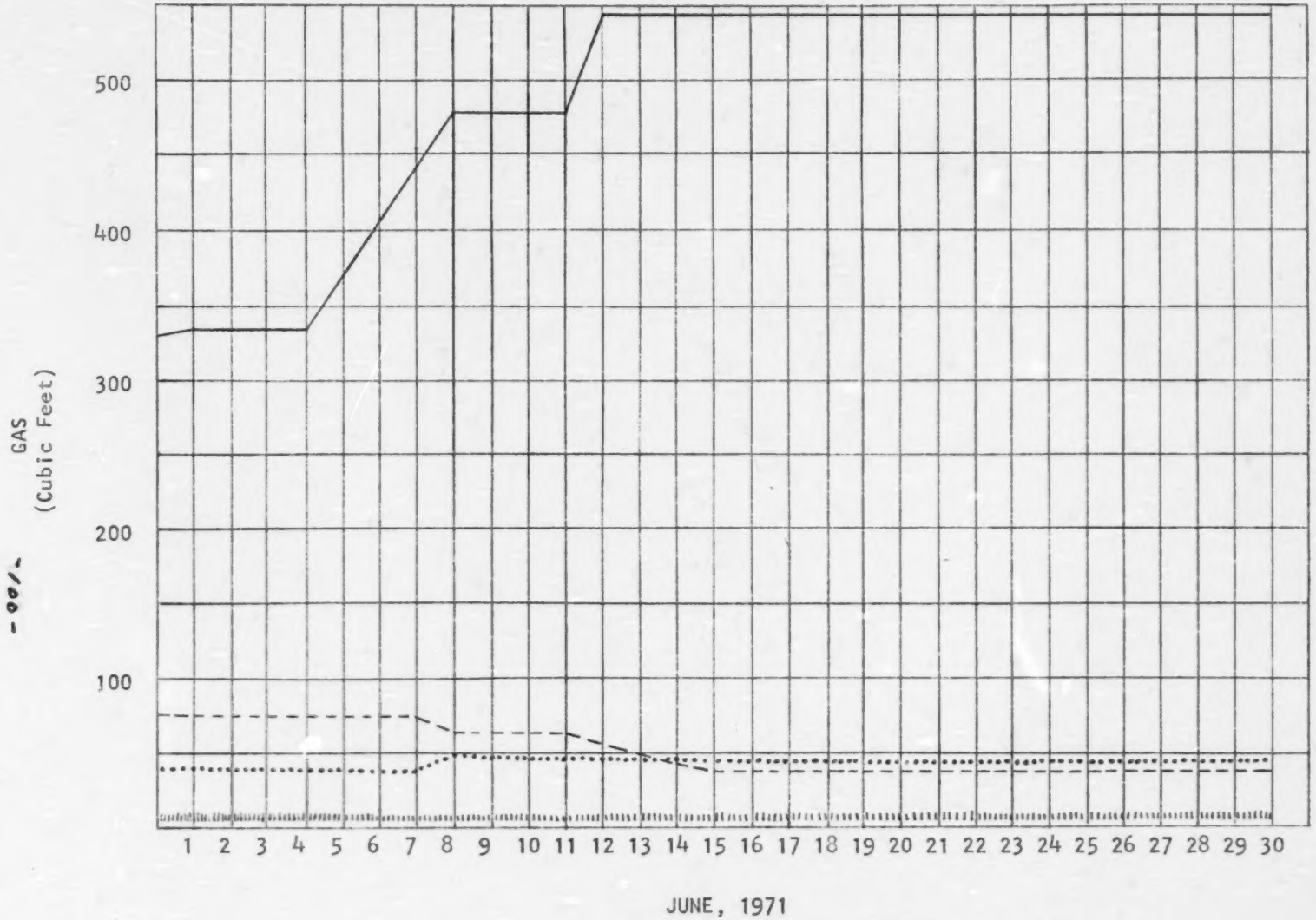
QUANTITY

Cell #1 (Conventional Refuse) ———

Cell #2 (Conventional Refuse) — — — —

Cell #3 (Shredded Refuse (2)) .....

Cell #4 (Shredded Refuse (6)) ||||||||||




GAS IN TEST CELLS
QUANTITY

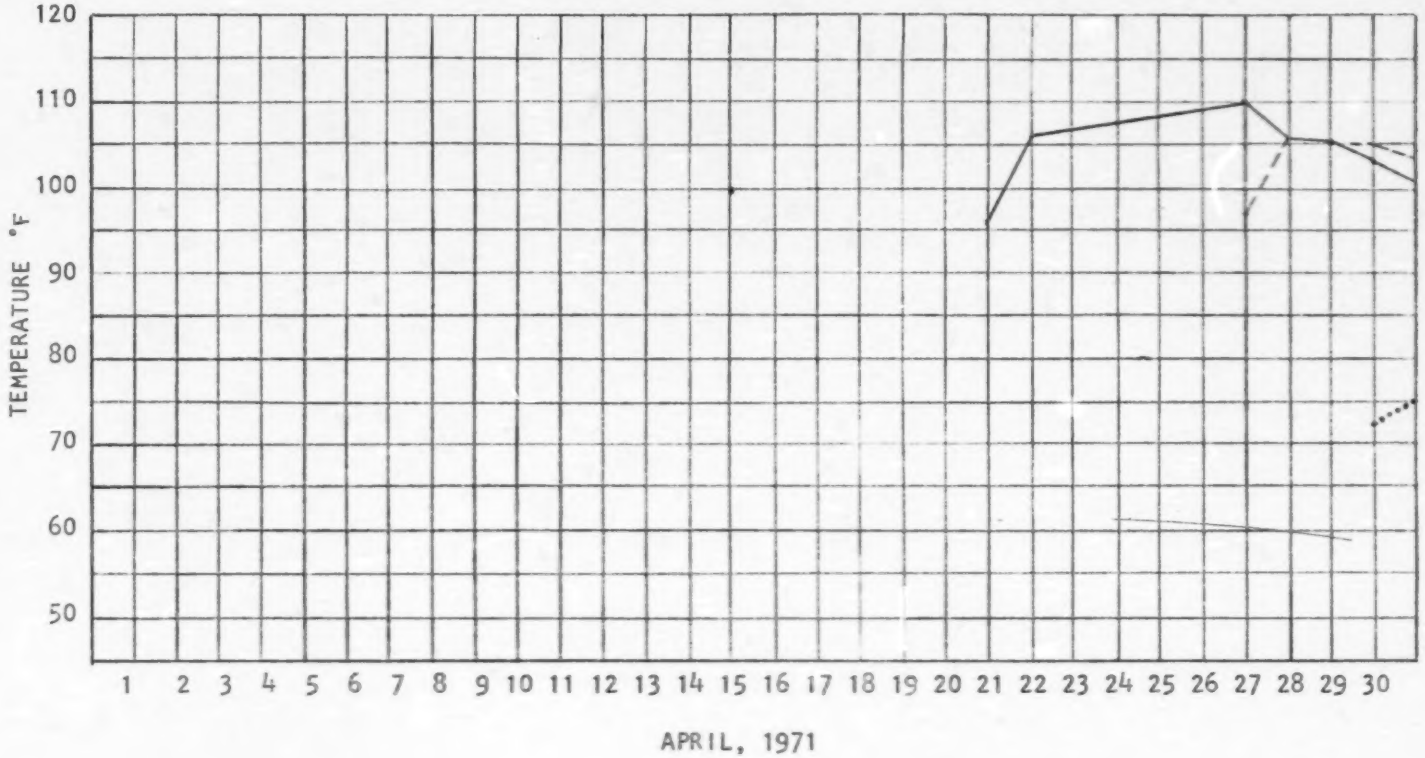
Cell #1 (Conventional Refuse) ————

Cell #2 (Conventional Refuse) — — — —

Cell #3 (Shredded Refuse (2)) .....

Cell #4 (Shredded Refuse (6)) ·····

CHART 3




TEMPERATURE IN TEST CELLS

Cell #1 (Conventional Refuse) ————

Cell #2 (Conventional Refuse) — — — —

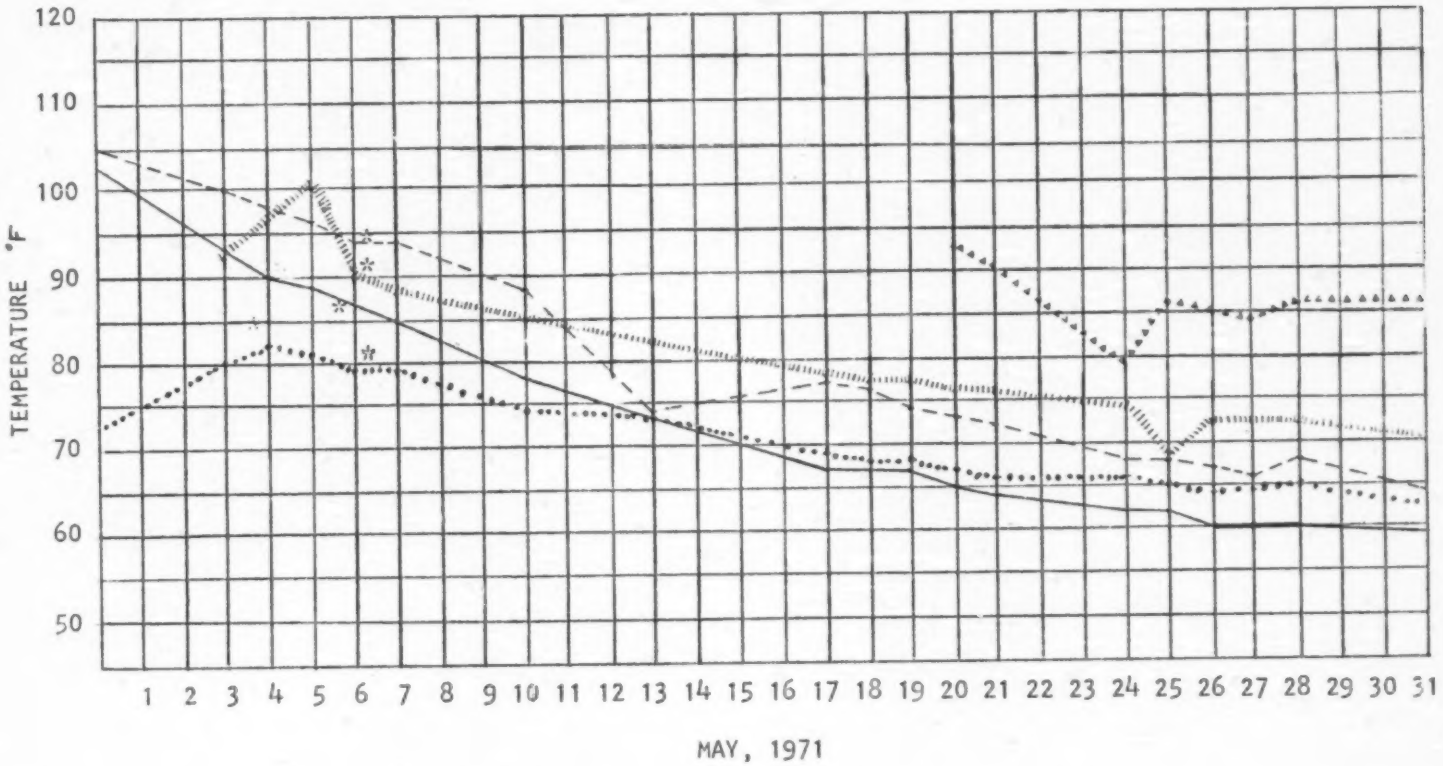
Cell #3 (Shredded Refuse (2)) . . . . . .

Cell #4 (Shredded Refuse (6)) ''''''''''

Cell #5 (Compost (28 days)) . . . . .

Cell #6 (Compost (56 days)) □ □ □ □

CHART 4




TEMPERATURE IN TEST CELLS

Cell #1 (Conventional Refuse) ———

Cell #2 (Conventional Refuse) — — —

Cell #3 (Shredded Refuse (2)) · · · · · · ·

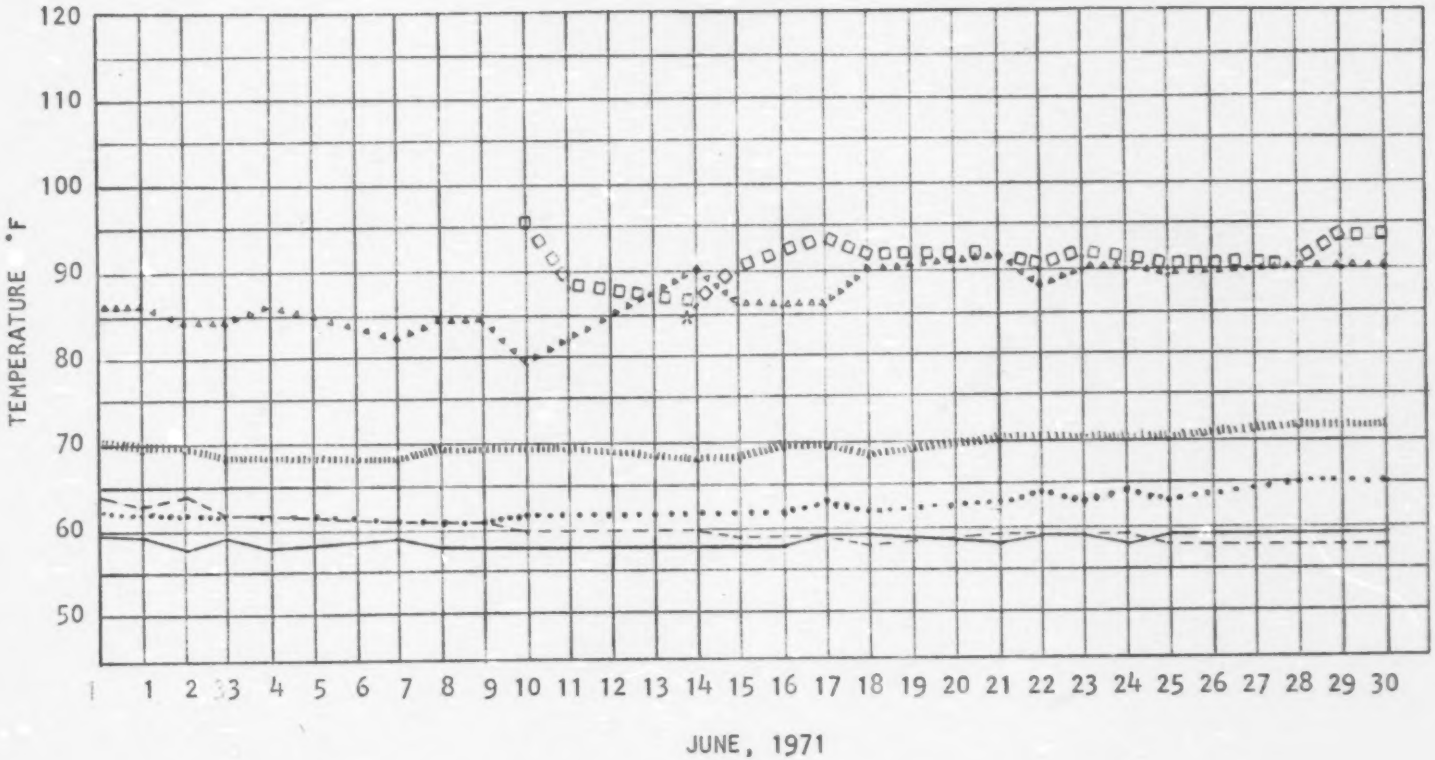
Cell #4 (Shredded Refuse (6)) ····· ····· ·····

Cell #5 (Compost (28 days)) ▲ ▲ ▲ ▲ ▲

Cell #6 (Compost (56 days)) □ □ □ □

* On May 6, 1971, 3.1 inches of rain fell, flooding the cells.

CHART 5




TEMPERATURE IN TEST CELLS

Cell #1 (Conventional Refuse) ———

Cell #2 (Conventional Refuse) — — — —

Cell #3 (Shredded Refuse (2)) . . . . . .

Cell #4 (Shredded Refuse(6)) ''''''''''''

Cell #5 (Compost (28 days)) ▲ ▲ ▲ ▲ ▲

Cell #6 (Compost (56 days)) □ □ □ □

* On June 14, 1971 Cell #6 was flooded.

TABLE VI-9

LEACHATE ANALYSIS CELL #1

| DATE | | 5-22-71 | 6-4-71 | 6-18-71 | 6-24-71 |
|---|---|---|---|---|---|
| TEMPERATURE | °C | 17°C | 17°C | 15°C | 17°C |
| pH | | 5.58 | 7.1 | ---- | 6.4 |
| D.O. | ppm | ---- | 77.1 | 0.08 | 4.4 |
| B.O.D. | Mg/l | 1236 | ---- | ---- | ---- |
| C.O.D. | Mg/l | 600 | ---- | ---- | 65.6 |
| TOTAL SOLIDS | Mg/l | 1.716 | 1.384 | ---- | 2.0 |
| DISSOLVED SOLIDS | Mg/l | 1.688 | 1.384 | ---- | ---- |
| VOLATILE SOLIDS | Mg/l | 1.040 | 0.604 | ---- | 4.0 |
| SUSPENDED SOLIDS | Mg/l | ---- | Trace | ---- | Trace |
| NITRATE | Mg/l | 8.0 | 11.0 | 30.8 | ---- |
| NITRITE | Mg/l | ---- | 0.072 | 0.0495 | ---- |
| PHOSPHATE-TOTAL | Mg/l | ---- | 6.20 | ---- | ---- |
| PHOSPHATE-ORTHO | Mg/l | 1.0 | 2.20 | ---- | ---- |
| VOLATILE ACIDS | Mg/l | ---- | 425 | ---- | ---- |
| SPECIFIC CONDUCTANCE | Micromhos / CM | ---- | 320 | 6750 | 1175 |
| CHLORIDES | ppm | 35 | 35 | ---- | ---- |
| ALKALINITY | Mg/l | ---- | 6.60 | ---- | ---- |
| TURBIDITY | | ---- | 4.0 | 9.0 | ---- |

TABLE VI-10

LEACHATE ANALYSIS CELL #2

| DATE | | 5-22-71 | 6-4-71 | 6-18-71 | 6-24-71 |
|---|---|---|---|---|---|
| TEMPERATURE | °C | 17° | 16° | 17° | 15° |
| pH | | 5.25 | 6.5 | ---- | 6.2 |
| D.O. | ppm | ---- | .33 | Trace | 5.75 |
| B.O.D. | Mg/l | 2272 | 43.0 | ---- | Trace |
| C.O.D. | Mg/l | 4100 | ---- | ---- | 772 |
| TOTAL SOLIDS | Mg/l | 3.788 | 5.480 | ---- | 4.776 |
| DISSOLVED SOLIDS | Mg/l | 3.812 | 5.460 | ---- | 4.628 |
| VOLATILE SOLIDS | Mg/l | 3.150 | 3.108 | ---- | 2.766 |
| SUSPENDED SOLIDS | Mg/l | ---- | 0.020 | ---- | 0.148 |
| NITRATE | Mg/l | 3.4 | 13.0 | 16.5 | ---- |
| NITRITE | Mg/l | ---- | 0.185 | 0.0198 | ---- |
| PHOSPHATE-TOTAL | Mg/l | 2.0 | 55.00 | ---- | ---- |
| PHOSPHATE-ORTHO | Mg/l | ---- | 9.50 | ---- | ---- |
| VOLATILE ACIDS | Mg/l | ---- | 550 | ---- | ---- |
| SPECIFIC CONDUCTANCE | Micromhos / CM | ---- | 1600 | 2950 | 4400 |
| CHLORIDES | ppm | ---- | 25 | 45 | ---- |
| ALKALINITY | Mg/l | ---- | -44.70 | ---- | ---- |
| TURBIDITY | | ---- | 360 | 370 | ---- |

TABLE VI-11

LEACHATE ANALYSIS CELL #3

| DATE | | 5-22-71 | 6-4-71 | 6-18-71 | 6-24-71 |
|---|---|---|---|---|---|
| TEMPERATURE | °C | 17° | 16° | 16° | 16° |
| pH | | 5.45 | 6.7 | ---- | 6.3 |
| D.O. | ppm | ---- | 0.50 | Trace | 6.33 |
| B.O.D. | Mg/l | 2252 | 67.5 | ---- | Trace |
| C.O.D. | Mg/l | 5950 | ---- | ---- | 756 |
| TOTAL SOLIDS | Mg/l | 7.3124 | 2.684 | ---- | 2.836 |
| DISSOLVED SOLIDS | Mg/l | 7.312 | 2.676 | ---- | 2.804 |
| VOLATILE SOLIDS | Mg/l | 5.030 | 1.180 | ---- | 1.312 |
| SUSPENDED SOLIDS | Mg/l | ---- | 0.008 | ---- | 0.032 |
| NITRATE | Mg/l | 4.6 | 12.0 | 17.6 | 10.0 |
| NITRITE | Mg/l | ---- | 0.163 | 0.02475 | Trace |
| PHOSPHATE-TOTAL | Mg/l | 3.0 | 73.0 | ---- | 4.40 |
| PHOSPHATE-ORTHO | Mg/l | ---- | 2.60 | ---- | Trace |
| VOLATILE ACIDS | Mg/l | ---- | 570 | ---- | ---- |
| SPECIFIC CONDUCTANCE | Micromhos / CM | ---- | 1300 | 5000 | 3990 |
| CHLORIDES | ppm | ---- | 185 | 85 | ---- |
| ALKALINITY | Mg/l | ---- | -24.80 | ---- | 1844 |
| TURBIDITY | | ---- | 200 | 97 | ---- |

TABLE VI-12

LEACHATE ANALYSIS CELL #4

| DATE | | 5-22-71 | 6-4-71 | 6-18-71 | 6-24-71 |
|---|---|---|---|---|---|
| TEMPERATURE | °C | 17° | 17° | 17° | 15° |
| pH | | 5.6 | 6.9 | ---- | 6.6 |
| D.O. | ppm | ---- | 2.0 | 0 | 6.55 |
| B.O.D. | Mg/l | 1658 | 77.1 | ---- | Trace |
| C.O.D. | Mg/l | 1500 | ---- | ---- | 10,600 |
| TOTAL SOLIDS | Mg/l | 4.5600 | 0.808 | ---- | 1.304 |
| DISSOLVED SOLIDS | Mg/l | 4.524 | 0.800 | ---- | 0.936 |
| VOLATILE SOLIDS | Mg/l | 1.930 | 0.508 | ---- | 0.692 |
| SUSPENDED SOLIDS | Mg/l | ---- | 0.008 | ---- | 0.368 |
| NITRATE | Mg/l | 0.6 | 11.0 | 15.4 | 11 |
| NITRITE | Mg/l | ---- | 0.53 | 0.033 | Trace |
| PHOSPHATE-TOTAL | Mg/l | 0.0 | 5.80 | ---- | 4.16 |
| PHOSPHATE-ORTHO | Mg/l | ---- | 1.80 | ---- | 0.40 |
| VOLATILS ACIDS | Mg/l | ---- | 510 | ---- | ---- |
| SPECIFIC CONDUCTANCE | Micromhos / CM | ---- | 460 | 13.750 | 2100 |
| CHLORIDES | ppm | ---- | 45 | 65 | ---- |
| ALKALINITY | Mg/l | ---- | 9.4 | ---- | 1420 |
| TURBIDITY | | ---- | 114 | 310 | ---- |

TABLE VI-13

LEACHATE ANALYSIS CELL #5

| | | | | | |
|---|---|---|---|---|---|
| DATE | | 5-22-71 | 6-4-71 | 6-18-71 | 6-24-71 |
| TEMPERATURE | °C | 16° | 18° | 19° | 19° |
| pH | | 5.62 | 6.8 | ---- | 6.1 |
| D.O. | ppm | ---- | 0.33 | Trace | 5.57 |
| B.O.D. | Mg/l | 2145 | 77.1 | ---- | Trace |
| C.O.D. | Mg/l | 2650 | ---- | ---- | 10,720 |
| TOTAL SOLIDS | Mg/l | 2.9440 | 4.988 | ---- | 9.348 |
| DISSOLVED SOLIDS | Mg/l | 2.9440 | 4.728 | ---- | 8.932 |
| VOLATILE SOLIDS | Mg/l | 2.9300 | 2.664 | ---- | 5.052 |
| SUSPENDED SOLIDS | Mg/l | ---- | 0.260 | ---- | 0.416 |
| NITRATE | Mg/l | 6.1 | 10.0 | 31.90 | 14.0 |
| NITRITE | Mg/l | ---- | 0.53 | 0.0495 | Trace |
| PHOSPHATE-TOTAL | Mg/l | 0.0 | 60.0 | ---- | 12.9 |
| PHOSPHATE-ORTHO | Mg/l | ---- | 10.3 | ---- | 12.9 |
| VOLATILE ACIDS | Mg/l | ---- | 570 | ---- | ---- |
| SPECIFIC CONDUCTANCE | Micromhos / CM | ---- | 2000 | 7750 | 7500 |
| CHLORIDES | ppm | ---- | Interference | Interference | ---- |
| ALKALINITY | Mg/l | ---- | 40.10 | ---- | 940 |
| TURBIDITY | | ---- | 395 | 125 | ---- |

TABLE VI-14

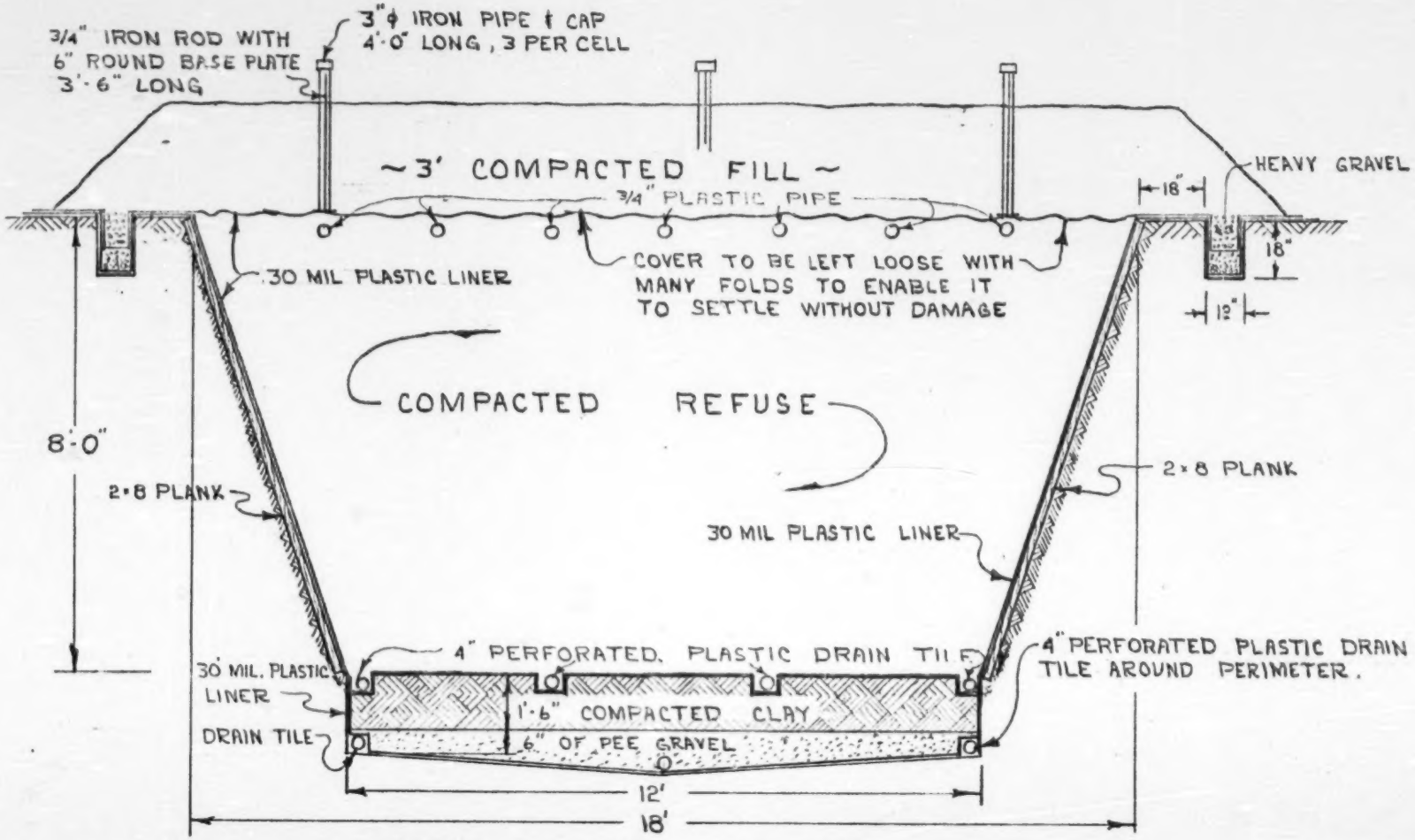
LEACHATE ANALYSIS CELL #6

| | | | |
|---|---|---|---|
| DATE | | 6-18-71 | 6-24-71 |
| TEMPERATURE | °C | 18° | 17° |
| pH | | ---- | 6.8 |
| D.O. | ppm | Trace | 6.13 |
| B.O.D. | Mg/l | ---- | 5.00 |
| C.O.D. | Mg/l | ---- | 10,000 |
| TOTAL SOLIDS | Mg/l | ---- | 4.0 |
| DISSOLVED SOLIDS | Mg/l | ---- | 4.0 |
| VOLATILE SOLIDS | Mg/l | ---- | 0.522 |
| SUSPENDED SOLIDS | Mg/l | ---- | Trace |
| NITRATE | Mg/l | 26.4 | 11.0 |
| NITRITE | Mg/l | 0.0594 | Trace |
| PHOSPHATE-TOTAL | Mg/l | ---- | |
| PHOSPHATE-ORTHO | Mg/l | ---- | |
| VOLATILE ACIDS | Mg/l | ---- | |
| SPECIFIC CONDUCTANCE | Micromhos / CM | 3750 | 1200 |
| CHLORIDES | ppm | 125 | |
| ALKALINITY | Mg/l | ---- | 2640 |
| TURBIDITY | | 225 | |

TABLE VI-15

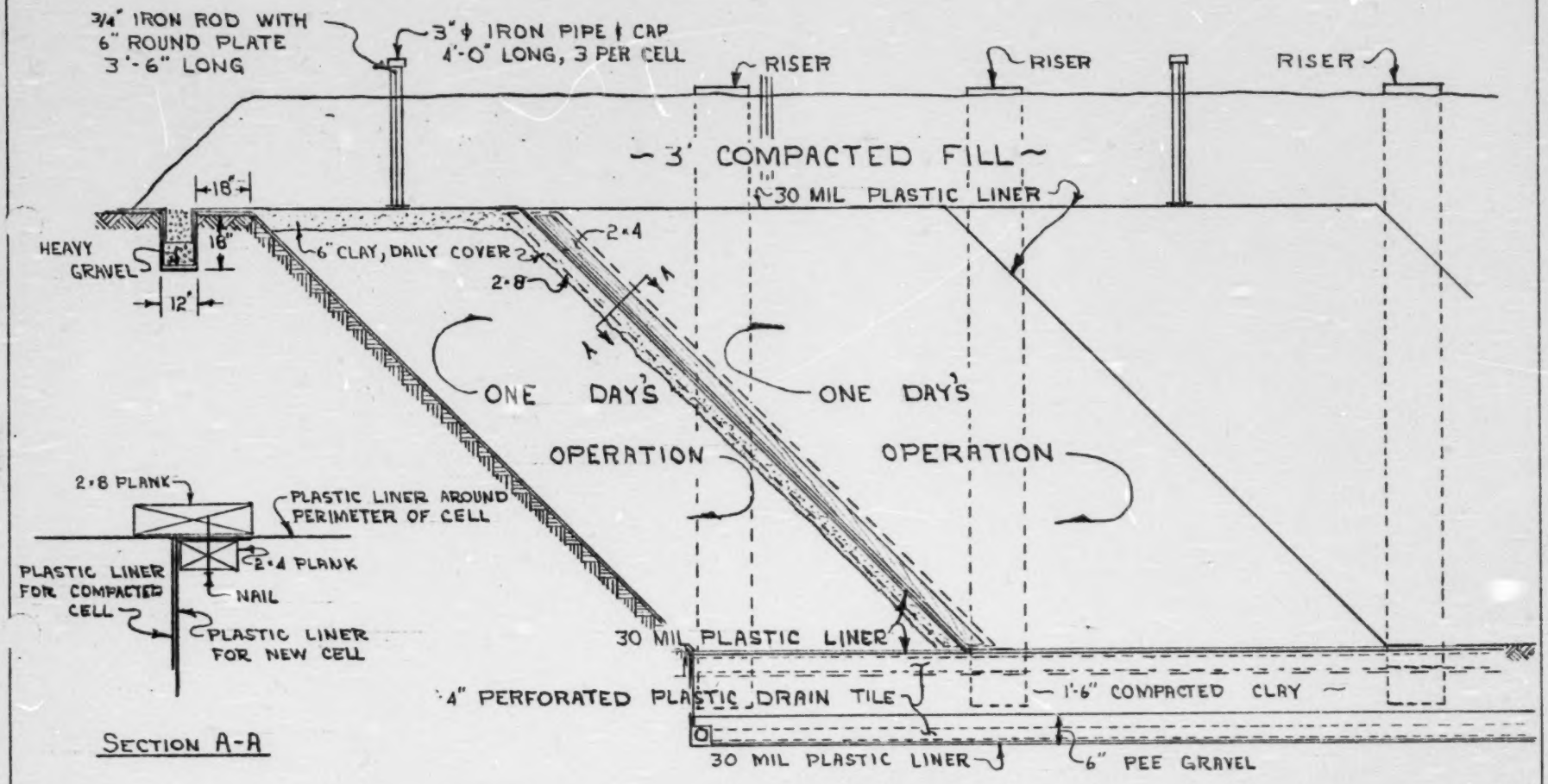
SETTLEMENT MONUMENTS

| DATE | MONUMENT | CELL #1 | CELL #2 | CELL #3 | CELL #4 | CELL #5 | CELL # |
|---|---|---|---|---|---|---|---|
| 5-17-71 | 1 | 100.53 | 99.64 | 99.52 | Settlement Monuments were not installed because of being disturbed when Cell #5 would be installed | | |
| | 2 | 100.08 | 100.07 | 99.67 | | | |
| | 3 | 100.07 | 100.04 | 99.71 | | | |
| 6- 9-71 | 1 | 100.52 | 99.60 | 99.47 | | Cells 5 and 6 were not covered until after June 30, 1971 | |
| | 2 | 100.06 | 100.04 | 99.54 | | | |
| | 3 | 100.03 | 100.01 | 99.66 | | | |



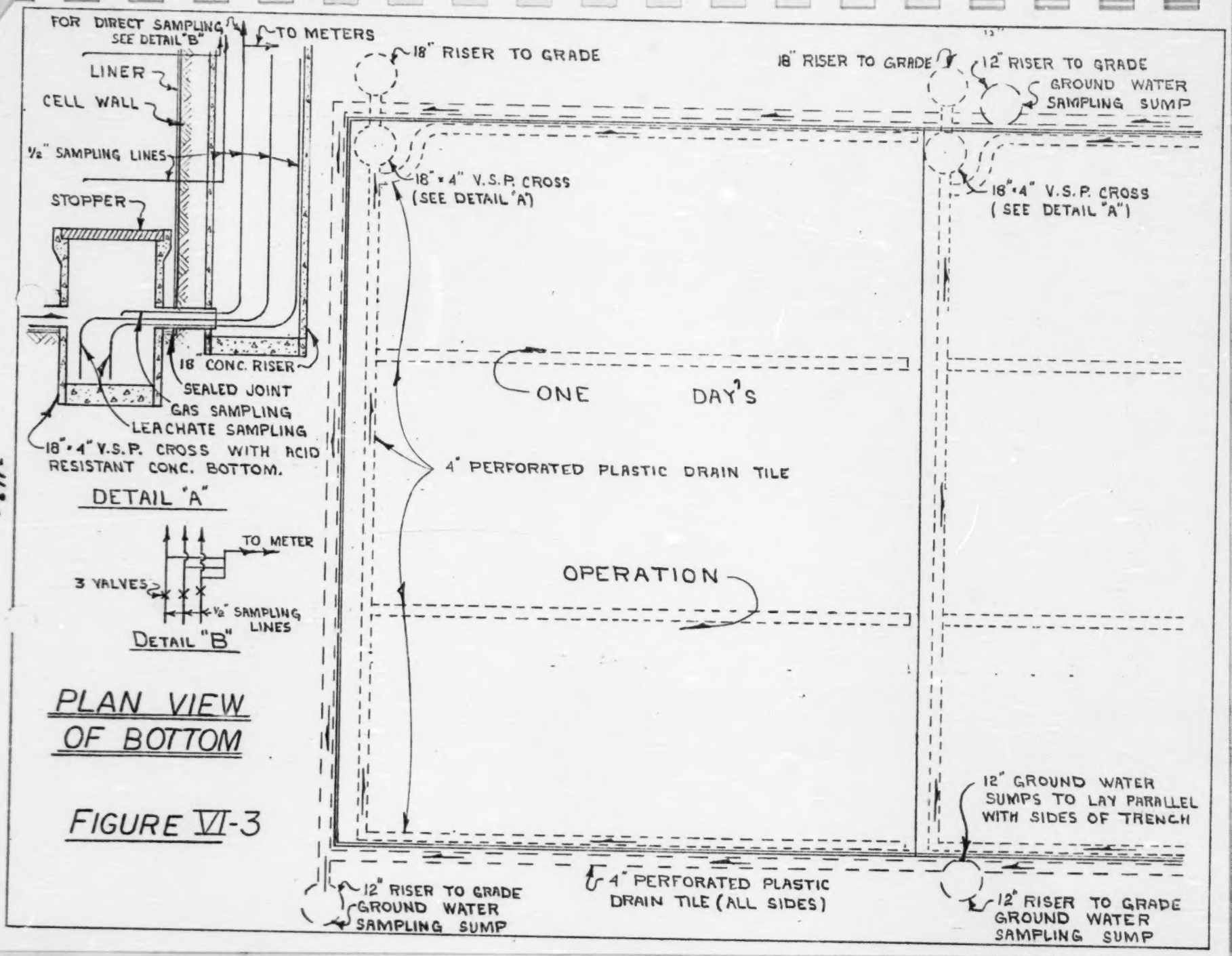

CROSS SECTION OF CELL

FIGURE VI-1



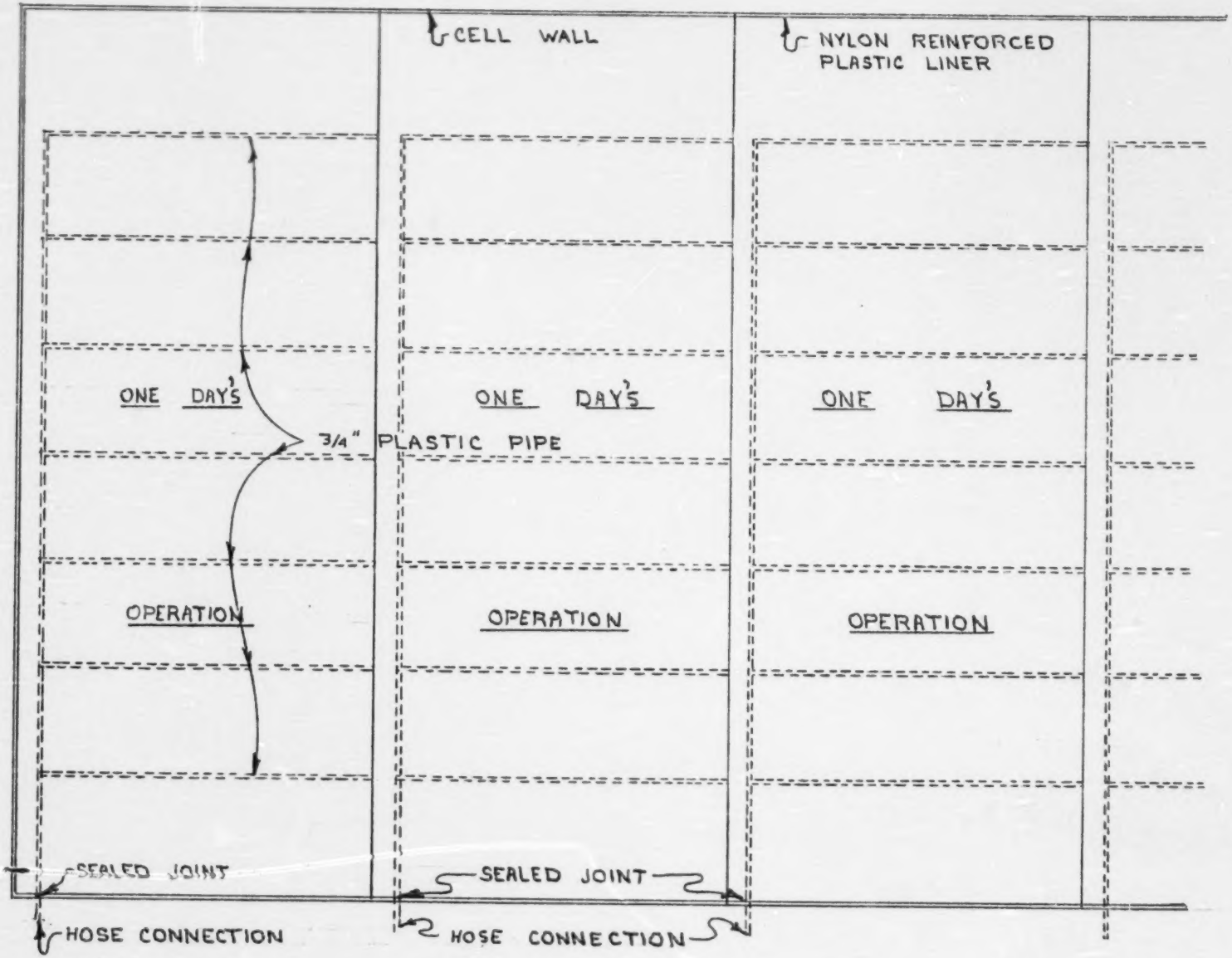

LONGITUDINAL CROSS SECTION

FIGURE VI 2



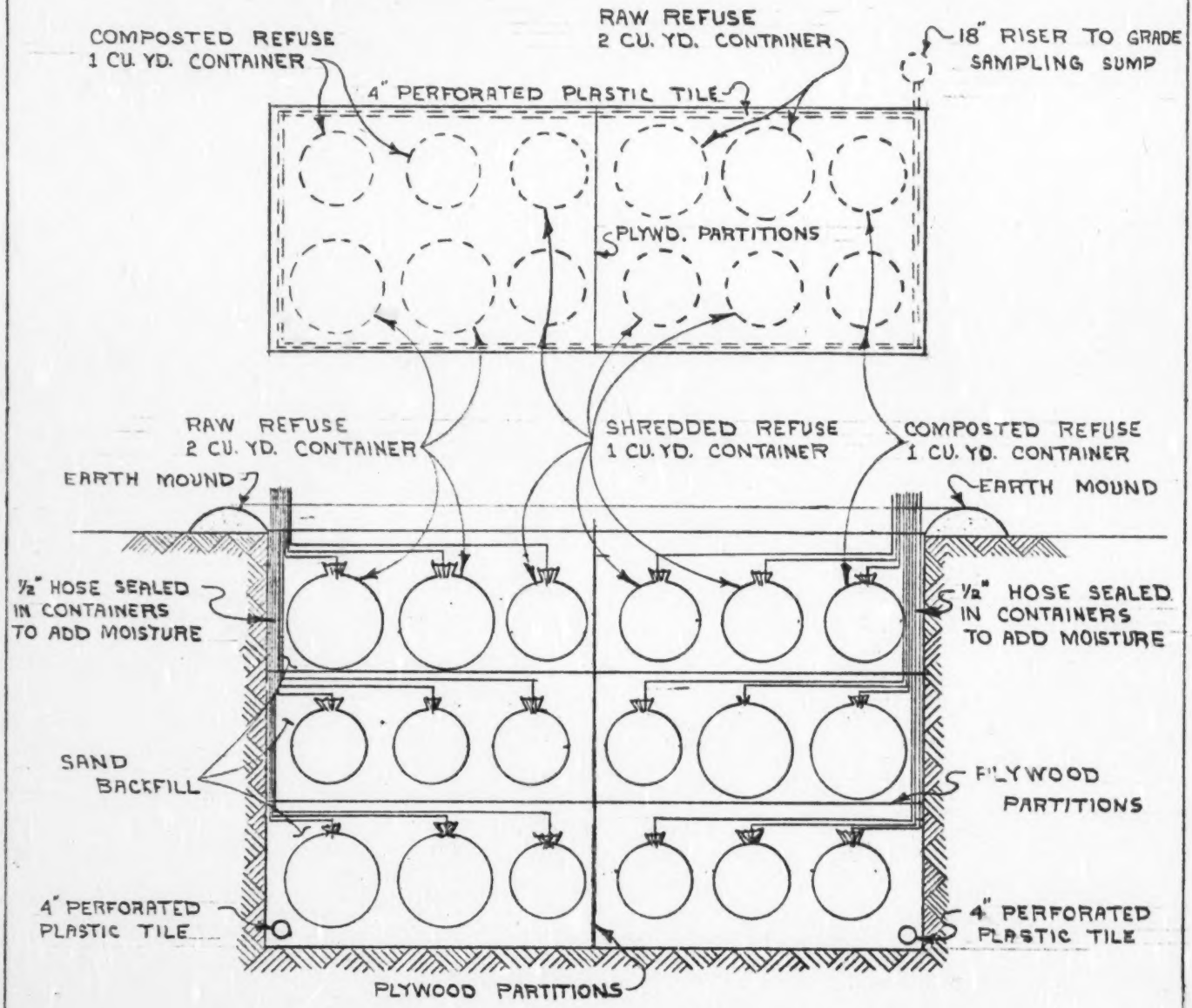

PLAN VIEW OF BOTTOM

FIGURE VI-3




PLAN VIEW OF TOP

FIGURE VI-5




CROSS SECTION & PLAN VIEW

FIGURE VI-4

APPENDIX E

ADDITIONAL READINGS OF CELL TEMPERATURES

AND WET GAS METERS

## LEACHATE SAMPLES COLLECTED

OCTOBER 18, 1972

| | Cell #1 | Cell #2 | Cell #3 | Cell #4 | Cell #5 | Cell #6 |
|---|---|---|---|---|---|---|
| pH | 5.8 | 5.9 | 5.7 | 6.8 | 7.2 | --- |
| BOD (mg/l) | 13,500 | 15,600 | 21,300 | 5,700 | 50 | 55 |
| COD (mg/l) | 19,000 | 23,400 | 32,000 | 7,500 | 318 | 280 |
| COD/BOD | 1.41 | 1.50 | 1.50 | 1.32 | 6.36 | 5.08 |
| Nitrates (mg/l) | 0 | 0 | 0 | 0 | 0 | 0 |
| Suspended Solids (mg/l) | 145 | 180 | 125 | 200 | 96 | 60 |
| Total Solids (mg/l) | 15,300 | 15,700 | 24,100 | 8,490 | 1,650 | 1,620 |
| Dissolved Solids (mg/l) | 15,155 | 15,520 | 23,975 | 8,290 | 1,554 | 1,560 |
| Specific Conductance (u mhos/cm) | 2,050 | 1,600 | 2,300 | 2,600 | 1,600 | 1,600 |
| Ammonia Nitrogen (mg/l) | 352 | 384 | 496 | 268 | 28 | 45 |
| Alkalinity (mg/l) | 10,300 | 10,200 | 12,100 | 5,700 | 1,800 | 1,640 |
| Volatile Solids (mg/l) | 6,870 | 7,310 | 11,600 | 3,860 | 409 | 398 |
| % of Volatile | 45 | 46 | 48 | 46 | 25 | 25 |
| Chlorides (mg/l) | 770 | 740 | 1,130 | 820 | 180 | 295 |
| Phosphate, Ortho (mg/l as $PO_4$) | 10.4 | 13.8 | 12.7 | 4.4 | 0.07 | 0.19 |
| Phosphate, Total (mg/l as $PO_4$) | 9.2 | 9.6 | 10.4 | 6.2 | 1.16 | 0.84 |
| Volatile Acids (mg/l as $CH_3COOH$) | 12,400 | 12,000 | 17,100 | 2,140 | 52 | 121 |

## LEACHATE SAMPLES COLLECTED

OCTOBER 25, 1972

| | Cell #1 | Cell #2 | Cell #3 | Cell #4 | Cell #5 | Cell #6 |
|---|---|---|---|---|---|---|
| pH | 5.9 | 5.9 | 5.7 | 6.3 | 6.8 | 7.1 |
| BOD (mg/l) | 14,300 | 16,200 | 21,100 | 12,400 | 168 | 69 |
| COD (mg/l) | 20,400 | 24,000 | 28,800 | 10,800 | 456 | 385 |
| COD/BOD | 1.42 | 1.48 | 1.36 | --- | 2.71 | 5.6 |
| Nitrates (mg/l) | 0 | 0 | 0 | 0 | 0 | 0 |
| Suspended Solids (mg/l) | 215 | 350 | 205 | 385 | 710 | 310 |
| Total Solids (mg/l) | 14,300 | 16,100 | 20,400 | 15,200 | 2,490 | 2,010 |
| Dissolved Solids (mg/l) | 14,085 | 15,750 | 20,195 | 14,815 | 1,780 | 1,700 |
| Specific Conductance (u mhos/cm) | 5,700 | 6,000 | 6,400 | 5,600 | 2,300 | 1,950 |
| Ammonia Nitrogen (mg/l as N) | 424 | 433 | 483 | 359 | 75.2 | 35.9 |
| Alkalinity (mg/l as $CaCO_3$) | 15,500 | 17,400 | 21,400 | 14,300 | 2,720 | 1,890 |
| Volatile Solids (mg/l) | 6,180 | 7,520 | 9,200 | 7,440 | 688 | 474 |
| % Volatile | 43 | 47 | 45 | 49 | 28 | 24 |
| Chlorides (mg/l as Cl) | 760 | 750 | 1,030 | 780 | 230 | 375 |
| Phosphate, Ortho (mg/l as $PO_4$) | 8.1 | 10.7 | 9.2 | 1.9 | 1.3 | 0.44 |
| Phosphate, Total (mg/l as $PO_4$) | 6.7 | 5.0 | 4.2 | 6.6 | 0.86 | 0.96 |
| Volatile Acids (mg/l as $CH_3COOH$) | 11,200 | 12,300 | 14,700 | 9,310 | 103 | 17 |

DATA TAKEN AFTER PROJECT

TEMPERATURE READING °F

| DATE | CELL #1 | CELL #2 | CELL #3 | CELL #4 | CELL #5 | CELL #6 |
|---|---|---|---|---|---|---|
| 8-26-71 | 62 | 60 | 65 | 71 | 83 | 78 |
| 10-12-71 | 63 | 62 | 67 | 68 | 72 | 68 |
| 10-27-71 | 62 | 60 | 65 | 64 | 68 | 64 |
| 11- 1-71 | 61 | 60 | 64 | 64 | 67 | 64 |
| 11- 4-71 | 61 | 60 | 64 | 64 | 68 | 66 |
| 11- 9-71 | 62 | 61 | 65 | 62 | 67 | 64 |
| 11-12-71 | 60 | 60 | 64 | 63 | 67 | 63 |
| 2-11-72 | 50 | 49 | 52 | 48 | 46 | 42 |
| 9- 7-72 | 66 | 63 | 66 | 66 | 66 | 68 |
| 10-18-72 | 67 | 62 | 104 | 63 | 64 | 61 |
| 10-25-72 | 63 | 62 | 102 | 61 | 61 | 59 |

## DATA TAKEN AFTER PROJECT

## WET TYPE GAS METER READING

| DATE | CELL #1 | CELL #2 | CELL #3 | CELL #4 | CELL #5 | CELL #6 |
|---|---|---|---|---|---|---|
| 8-26-71 | 1166 | 167 | 47 | 7 | ---- | ---- |
| 10-12-71 | 166.5 | 167.2 | 47.1 | 8.2 | 0.0 | 8.8 |
| 10-26-71 | ---- | ---- | 46.1 | 8.4 | 0.3 | 8.8 |
| 10-27-71 | 150.5 | 166.6 | 46.9 | 8.6 | 0.5 | 8.2 |
| 11- 1-71 | 150.5 | 166.8 | 47.0 | 8.6 | 0.5 | 8.2 |
| 11- 4-71 | 148.0 | 166.8 | 47.0 | 8.6 | 0.5 | 8.2 |
| 11- 9-71 | 148.0 | 166.7 | 47.0 | 8.6 | 0.5 | 8.2 |
| 11-12-71 | 148.0 | 166.8 | 47.0 | 8.6 | 0.5 | 8.3 |
| 2-11-72 | 193.1 | 166.8 | 47.2 | 8.6 | 0.5 | 8.3 |
| 7-26-72 | 193.1 | 166.8 | 47.2 | 8.5 | 0.5 | 8.2 |
| 9- 7-72 | 193.1 | 166.7 | 47.2 | 8.5 | 0.5 | 8.2 |
| 10-18-72 | 140.0 | 166.7 | 47.2 | 8.5 | 0.5 | 8.2 |
| 10-25-72 | 145.0 | 167.3 | 46.9 | 8.7 | 0.5 | 8.3 |

## LEACHATE ANALYSIS PROCEDURES

### INSTRUMENT ANALYSIS

1. pH

   a. Allow meter to warm up for 30 minutes.

   b. Standarize meter with a 7.0 pH buffer solution and make temperature adjustment.

   c. Clean probe with distilled water and wipe with a clean cloth or tissue.

   d. Place probe in sample and read the pH. Replace probe in beaker of distilled water.

2. SPECIFIC CONDUCTANCE OR CONDUCTIVITY

   a. Standarize the meter by adjustment while probe is dry and in air and temperature indicator is on 20°C.

   b. Set temperature indicator to correspond to temperature of the sample. Submerse probe so that the small air holes are at least one-half inch below surface. Make sure no air is trapped inside probe by shaking probe while submerged.

   c. Read ppm Conductivity on scale and convert to micro Mho units by use of scale provided with instrument.

   d. Clean probe thoroughly with distilled water after use and allow to dry.

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## LEACHATE ANALYSIS PROCEDURES

### AMMONIUM NITRATE

a. Measure 25 ml of 1:100 dilution leachate sample with a graduate cylinder and pour into a clean 125 ml flask.

b. Measure 25 ml distilled water with a graduate cylinder and pour into a clean 125 ml flask.

c. Make sure temperature of sample is 20°C before proceeding since temperature variance causes error in this equipment.

d. Add one drop of Rochelle Salt Solution to each flask.

e. Add 1.0 ml of Nessler's Reagent to each flask and swirl to mix.

f. Allow ten minutes for full color development characterized by a yellow color.

g. Use the prepared sample in a 1/2 inch test tube to standardize the Bausch & Lomb Spectronic 20 set at 425 mm.

h. Measure the percent transmittance of the sample and find the ppm of Ammonium Nitrogen from the calibration table.

i. Solutions:

1. Rochelle Salt Solution. Dissolve 50 g potassium sodium tartrate tetrahydrate, $KNaC_4H_4O_6 \cdot 4H_2O$ in 100 ml ammonia-free water. Remove the ammonia usually present in the salt by boiling off 30 ml of the solution. After cooling, dilute to 100 ml.

2. Nessler's Reagent. Dissolve 100 g Mercuric Iodide, $HgI_2$, and 70 g potassium iodide, KI, in a small quantity of ammonia-free water and add this mixture slowly, with stirring, to a cool solution of 160 g NaOH in 500 ml ammonia-free water. Dilute to 1 liter with ammonia-free water. Store out of sunlight.

## LEACHATE ANALYSIS PROCEDURES

### VOLATILE ACIDS

a. Clear a few milliliters by filtration or centrifugation.

b. Pipet exactly 0.5 ml of leachate sample into a clean 3/4 inch test tube to be used with the Bausch & Lomb Spectronic 20.

c. Into another clean test tube pipet exactly 0.5 ml demineralized water.

d. Add 1.50 ml Ethylene Glycol to each tube.

e. Add 0.20 ml of the diluted sulfric acid to each tube and mix well by swirling.

f. Heat in a boiling water bath for exactly 3 minutes.

g. Immediately cool in cold water.

h. Add 0.5 ml hydroxylamine solution.

i. Add 2.0 ml of 4.5N sodium hydroxide and swirl to mix well.

j. Add 10 ml ferric chloride solution to the test tubes.

k. Add 5.0 ml of distilled water to each and invert to mix.

l. Allow color development for 5 minutes.

m. Using the prepared blank to standardize the instrument at 500 mm read the percent transmittance and find the ppm volatile acids from the calibration table.

n. Standard Solutions:

1. Sulfuric Acid, Diluted. Mix equal volumes of reagent grade, concentrated sulfuric acid and distilled water. CAUTION: Always add acid to water--never water to acid.

2. Ethylene Glycol, Reagent Grade. Use as purchased.

3. Sodium Hydroxide 4.5N. Dissolve 90 grams of sodium hydroxide pellets in distilled water and dilute up to 500 ml.

4. Hydroxylamine Solution, 10 percent. Dissolve 10 g of hydroxylene hydrochloride in distilled water and make up to 100 ml.

5. Ferric Chloride Reagent. Dissolve 20 g of ferric chloride hexahydrate ($Fe\ Cl_3$-6 HeO) in distilled water, add 20 ml of concentrated sulfuric acid and dilute to 1 liter.

## LEACHATE ANALYSIS DETERMINATION

### ALKALINITY

a. Take a 20 ml sample of leachate and titrate with o.02 N $H_2SO_4$ titrate from the original pH to a pH of 8.3 using a pH meter to determine the change. Mix $H_2SO_4$ well while titrating. Record the ml $H_2SO_4$ needed.

b. Titrate further to a pH of 4.5 and record total volume of acid used to reach this point.

c. Calculations:

Let: P = Amount of $H_2SO_4$ in ml from Part "a"

T = Total $H_2SO_4$ in ml from Part "b"

| RESULT OF TITRATION | HYDROXIDE ALKALINITY AS $CaCO_3$ | CARBONATE ALKALINITY AS $CaCO_3$ | BICARBONATE ALKALINITY AS $CaCO_3$ |
|---|---|---|---|
| P = 0 | 0 | 0 | T |
| P < 1/2 T | 0 | 2P | T - 2P |
| P = 1/2 T | 0 | 2P | 0 |
| P > 1/2 T | 2P - T | 2 (T-P) | 0 |
| P = T | T | 0 | 0 |

## LEACHATE ANALYSIS PROCEDURES

### COMMERCIAL PROCEDURES

1. CHLORIDES

   a. Accurately pipet a 10 ml sample of 1:10 dilution of leachate into a 50 ml titrate flask.

   b. Add the contents of one HACH DIPHENYL-CARBONZONE Indicator, Buffer Powder Pillow and swirl to mix.

   c. Titrate the sample with Mercuric Nitrate Solution until the color changes from yellow to purple.

   d. Calculations:

      ppm Chlorides - ml of Mercuric Nitrate x 500

2. ORTHO PHOSPHATE

   a. Accurately measure 25 ml of 1:100 dilution of leachate in a graduate cylinder. Pour the sample into a 125 ml Erlenmeyer flask.

   b. Add the contents of one HACH Phosver III Powder Pillow, immediately swirl to mix. Allow color, a blue-violet, to develop from one to two minutes.

   c. Using a Bausch & Lomb Spectronic 20 set at 700 mm with a 1/2 inch test tube measure the percent transmittance of the sample. The instrument is standarized by using the untreated sample.

   d. Find the ppm of phosphate ($PO_4$) from the calibration table.

3. TOTAL PHOSPHATE

   a. Accurately measure 25 ml of 1:100 dilution of leachate sample in a graduate cy'inder. Pour the sample into a 125 ml Erlenmeyer flask.

   b. Add the contents of one HACH Acid Powder Pillow for phosphate and swirl to mix.

   c. Boil the sample for 10 minutes and cool to room temperature.

   d. By adding distilled water bring the sample volume back to 25 ml.

e. Add the contents of one HACH Neutralizing Powder Pillow for phosphate and swirl to mix.

f. Proceed with Step 2 of the Orthophosphate test except read the ppm phosphate as total inorganic phosphate.

4. NITRATE NITROGEN

a. Measure 25 ml of 1:100 dilution leachate sample in a graduate cylinder. Pour the sample into a clean, rinsed, 125 ml Erlenmeyer flask.

b. Add the contents of one HACH Nitraver IV Powder Pillow, stopper the flask and shake vigorously for 1 minute. Allow color, a red, to develop for 3 minutes.

c. Using a Bausch & Lomb Spectronic 20 set at 525 mm with a 1/2 inch test tube, measure the percent transmittance of the sample. The instrument is standardized by using the untreated sample.

d. Find the ppm Nitrate Nitrogen from the calibration table.

## LEACHATE ANALYSIS PROCEDURES

### BIOCHEMICAL OXYGEN DEMAND - BOD

a. Using a 1:100 sample concentration make two each of the following sample dilutions in standard BOD incubation bottles.

| ml Sample @ 1:100 | ml Dilution Water | Dilution Ratio |
|---|---|---|
| 30 | 270 | 1:1000 |
| 15 | 285 | 1:2000 |
| 5 | 295 | 1:6000 |

b. Place one each of the bottles in a constant temperature 20°C incubator for 5 days.

c. After 15 minutes determine the dissolved oxygen of remaining samples by the following procedure.

1. To a sample bottle add 2 ml manganous sulphate solution followed by 2 ml Alkali-Azide reagent. Shake well and let precipitate settle.

2. Shake again and let precipitate settle and add 2 ml of concentrated $H_2SO_4$. Shake again.

3. Determine the dissolved oxygen using the Spectronic 20 Colorimeter and the calibration chart.

d. After five days repeat this procedure on the incubated samples.

e. Calculation:

$$\text{Mg/l BOD} = (DO_i - DO_f) \times D_r$$

Where: Di = DO initial after 15 minutes
Df = DO final after 5 days
Dr = Appropriate dilution ratio

f. For solutions see Standard Methods, page 406 and page 415.

## LEACHATE ANALYSIS PROCEDURES

### CHEMICAL OXYGEN DEMAND - COD

a. Place 10 ml of sample into a refluxing flask. Samples should be diluted using two ratios, 1:100 and 1:50, and a distilled water flask.

b. Add .2g $HgSO_4$ to the flask using the Hack Company measuring spoon and swirl to mix.

c. Add 5 ml 0.25 N Dichromate solution.

d. Add 15 ml concentrated $H_2SO_4$ - $AgSO_4$ with mixing.

e. Add a few glass beads to prevent bumping and reflux the mixture for 2 hours.

f. Bring the volume to 29 ml with distilled water and determine the ppm COD using the Spectronic 20 colorimeter and the calibration chart and the dilution factors.

g. For additional information see Standard Methods, page 510.

## LEACHATE ANALYSIS PROCEDURES

### SOLIDS DETERMINATION

1. TOTAL SOLIDS

   a. Evaporate 50 ml of sample in an ignited and tared heavy duty dish over boiling water to dryness.

   b. Dry for one hour at 103°C in an oven and cool in a desiccator and weigh.

   c. Save dish and residue for Total Volatile Solids Test.

   d. Calculation:

   Total Solids in

$$\text{Mg/l} = \frac{\text{Final Weight - Initial Weight in mg} \times 1000}{50 \text{ ml}}$$

2. SUSPENDED SOLIDS

   a. Filter 25 ml of sample through a dry tared crusible and filter using a vacuum apparatus.

   b. Leaving the suction or rinse container and crusible with a small amount of distilled water to obtain accurate results.

   c. Dry the filter crusible and solids at 103°C for one hour, allow to cool at room temperature in a desiccator and weigh.

   d. Calculation:

   Suspended Solids in

$$\text{Mg/l} = \frac{\text{Final Weight - Initial Weight in mg} \times 1000}{25 \text{ ml}}$$

3. DISSOLVED SOLIDS

   a. Calculation:

   Total Solids - Suspended Solids = Dissolved Solids

4. TOTAL VOLATILE SOLIDS

   a. Ignite the dish and residue from the total solids test in an electric muffle furnace for 20 minutes at 600°C.

b. Allow to cool partially in air and then cool in a desiccator for 30 minutes and weigh.

c. Calculation:

$$\text{Total Volatile Solids in Mg/l} = \frac{\text{Final Weight} - \text{Initial Weight in mg} \times 1000}{50 \text{ ml}}$$

## SOLIDS ANALYSIS PROCEDURES

1. MOSITURE CONTENT AND PERCENT DRY SOLIDS

   a. Place sample into previously conditioned and weighed crusible, weigh sample plus crusible.

   b. Dry at 101° - 108°C until constant weight is reached.

   c. Allow to cool in a desiccator until room temperature is reached and accurately weigh the sample and crusible.

   d. Calculations:

   $$\text{Percent Moisture} = \frac{\text{Initial Wt.} - \text{Dry Wt.} \times 100}{\text{Initial Wt.}}$$

   $$\text{Percent Dry Solids} = \frac{\text{Dry Wt.}}{\text{Initial Wt.}} \times 100$$

2. PERCENT VOLATILE SOLIDS AND PERCENT ASH

   a. Place crusible and sample from test No. 1 in a muffle furnace for three hours at 750°C.

   b. Cool five minutes in the atmosphere and then cool 30 minutes in a desiccator.

   c. Calculations:

   $$\text{Percent Volatile Solids} = \frac{\text{Initial Wt.} - \text{Final Wt.}}{\text{Initial Wt.}} \times 100$$

   $$\text{Percent Ash} = \frac{\text{Final Wt.}}{\text{Initial Wt.}} \times 100$$

3. CARBON - Nitrogen Ratio

   A. Carbon Calculations - (8.0% Accurate)

      a. Raw Garbage - Percent Carbon = $\frac{100-\%\ \text{Ash}}{1.97}$

      b. Remaining Combustibles - % Carbon = $\frac{100-\%\ \text{Ash}}{2.18}$

      c. Total Combustibles - % Carbon = $\frac{100-\%\ \text{Ash}}{2.08}$

B. Nitrogen Determination (Kjeldahl)

a. Dry 0.1-0.5 grams of sample at 105°C until constant weight is reached. Place sample into 500 ml flask (Kjeldahl). Add 40 ml conc. sulfric acid, 26.8 gm potassium sulphate, and 6 ml mercuric sulphate. Digest slowly until frothing ceases and for 20 minutes after the liquid becomes "water clear."

b. Cool and dilute to 350 ml with distilled water.

c. Make alkaline with hydroxide - thiosulphate solution using phenolphthalein as an indicator. Distill into 50 ml of boric acid solution until 200 ml distillate has been collected. The temperature in the condenser should not rise above 29°C.

e. Calculations:

$$\text{Mg/l Organic N} = \frac{\text{ml } H_2SO_4 \text{ for Sample} - \text{ml for blank} \times 280}{\text{gram of Sample}}$$

f. Standard Solutions:

1. Hydroxide - Thiosulfate. Dissolve 500 g NaOH and 25 g $Na\ S_2\ O_3 - 5H_2O$ in distilled water and dilute to one liter.

2. Boric Acid Solution. 20g boric acid plus 10 ml of mixed indicator and dilute to one liter.

3. Mixed Indicator. Two volumes of 0.2% methyl red, one volume of 0.2% methylene blue in 95% ethyl alcohol.

4. SIZE DISTRIBUTION

a. Select a representative sample of refuse weighing from 8 to 10 pounds.

b. Separate the sample with the use of four screens whose effective openings are 7, 3-1/2, 1-1/2, and 3/4 inches respectively.

c. Present results as percent retained on each sieve.

5. REFUSE COMPOSITION

a. After the sample has been separated and size distribution calculated, it should be hand separated and placed in the following categories:

Paper, Rags, Glass, Metal, Plastic, Wood and Yard Trimmings, Garbage and Fines.

b. All material passing the 3/4" sieve will be considered garbage and need not be further separated, except for larger pieces of glass and metal.

c. Results should be expressed as percent of the total in each category.

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